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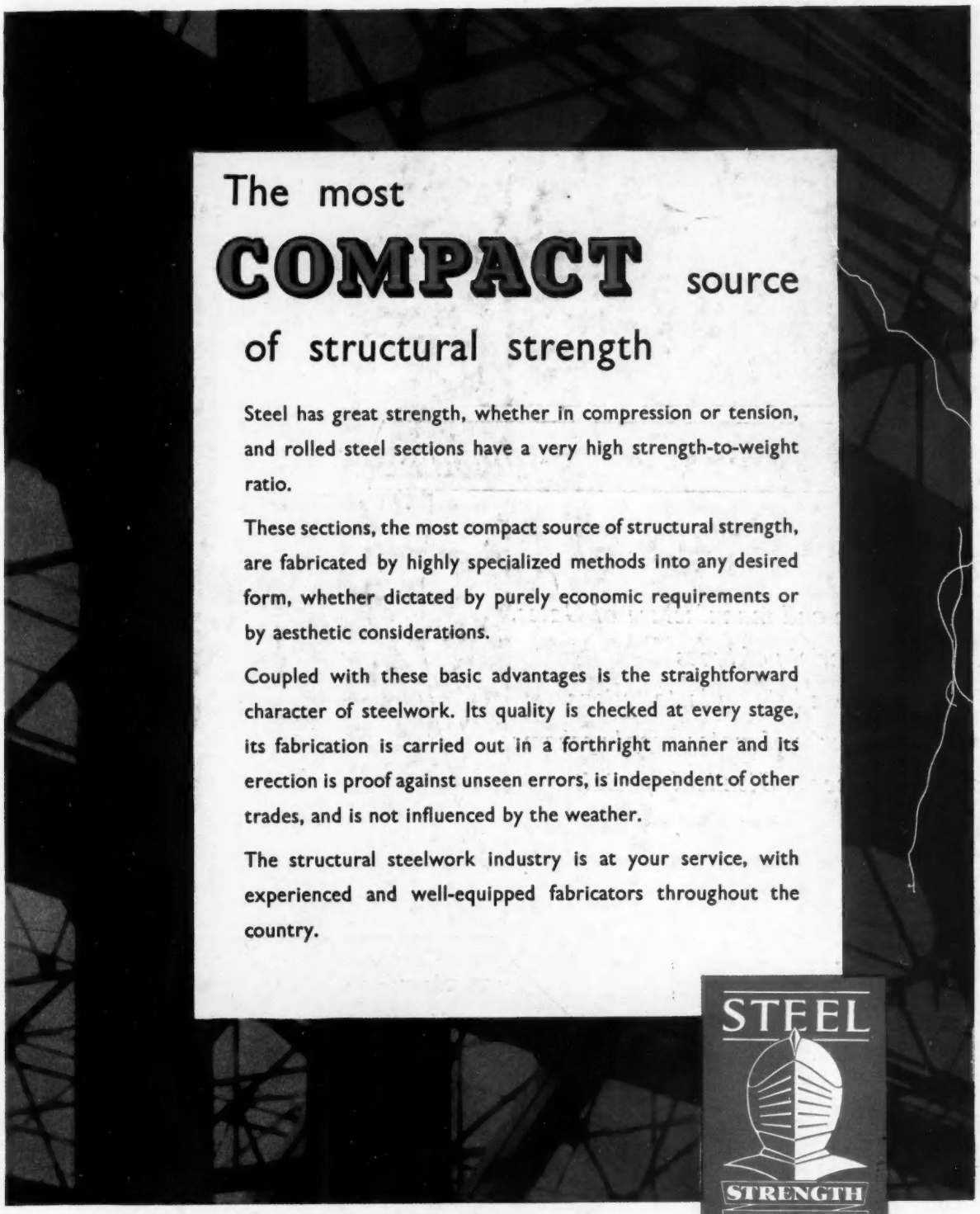
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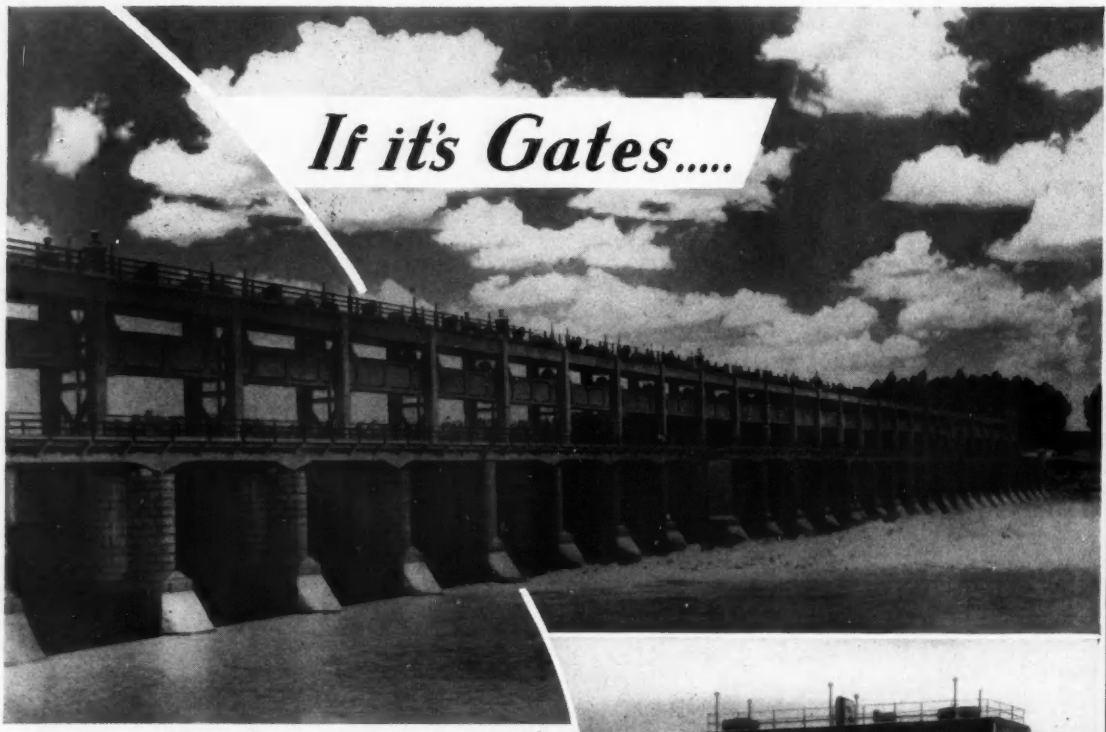

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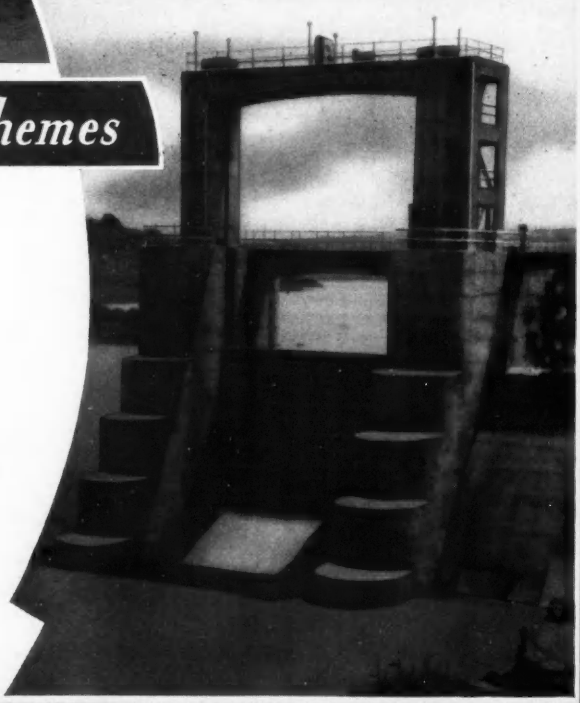

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THE ENGINEER

VOL. 201 No. 5236 JUNE 1, 1956

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DIESEL-ELECTRIC LOCOMOTIVES

The much publicised plan for the gradual elimination of steam traction on British Railways was followed in November last by the announcement of preliminary orders for 171 diesel locomotives. These orders form the basis of a pilot scheme by which the new power can be tested out on a considerable scale before bulk orders are placed. The plan itself, it will be recalled, envisages the construction of approximately 2500 diesel locomotives. In the pilot scheme orders have been placed for locomotives in three categories: Type A, 800–1000 h.p., for freight; Type B, 1000–1250 h.p., for mixed traffic, and Type C, 2000 h.p., or over, for heavy duties. The British Transport Commission has recently published, in a bulletin prepared under the auspices of the Locomotive Testing Joint Sub-Committee, the test results obtained with the 2000 h.p. diesel-electric locomotive No. 10203. The actual results are discussed in an article we publish elsewhere in this issue; but the performance of the locomotive, and the speed and haulage capacity revealed are of particular interest in providing a foretaste of what may reasonably be expected from the type C locomotives now on order under the pilot scheme. It might be argued that No. 10203 is no more than a prototype, and that considerably improved performance may be expected from the newer locomotives, which will presumably embody the fruits of experience gained, not only with No. 10203 but with the earlier diesel-electric locomotives of 1750 h.p. built originally to the orders of the London Midland and Scottish Railway, and of the Southern Railway, respectively. But the technical performance of No. 10203 was very good, and any improvements in the basic power relations are unlikely.

It is important to appreciate the limitations as well as the potentialities of a diesel-electric locomotive having a nominal horsepower of 2000, for to those not wholly familiar with this form of motive power the quoted rating might prove misleading. The designed rail tractive effort characteristic shows a drawbar pull of approximately 4·3 tons at 60 m.p.h., and of 3·8 tons at 70 m.p.h.; these are equivalent to 1550 and 1570 d.b.h.p. on the level at those respective speeds, at maximum power output. The average efficiency at the rail was found to be 25½ per cent, and it was demonstrated that this does not fall at part load ratings down to 38 per cent of full output, in fact, the value rises to 27 per cent at intermediate part-load ratings under service conditions. A very important factor revealed by the tests is that the diesel engine had fallen no more than 4 per cent in efficiency, and no more than 3 per cent in power at full load, after completion of 106,000 miles of running—2865 hours—without more than normal servicing. In addition to tests with special trains at specified engine speeds, corresponding to the controlled road tests and constant rates of evaporation run with various types of steam locomotives, No. 10203 was tested with the dynamometer car on certain service trains of the Southern Region between Waterloo and Exeter Central. One example may be briefly quoted: in running a heavy train of fourteen corridor coaches, 464 tons tare, from Waterloo to Salisbury at a running average speed of 53·5 m.p.h., including slowing-down and recovery from two intermediate stops, the average tractive drawbar horsepower was 995, and the tractive efficiency 20·7 per cent. If this latter figure is related to the ratio of trailing load to total load the tractive efficiency of the locomotive at the rail becomes 26·7 per cent. This confirmation of design characteristics, and relations determined in the controlled tests, by the results of runs with service trains is an important feature of the bulletin published by the British Transport Commission. Considerable space is devoted in the bulletin to the very careful cross-check methods employed by the Swindon Experimental and Locomotive Testing Station, which was responsible for the trials, to ensure that reconciliation between theory and practice is, in fact, complete.

When so much locomotive testing work done over the past fifty or sixty years has been so sketchy and unconvincing it is good to know that such precise methods of checking up afterwards are now a regular procedure. But in another respect the tests on locomotive No. 10203 are not so reassuring. The type C locomotives in the new pilot scheme are designated for heavy duties. None of these locomotives has a rated horsepower above 2300, and yet on the results obtained from

No. 10203, a drawbar horsepower of not more than about 1600 on the level at 60 to 70 m.p.h. may be expected from them. One of the most interesting points of analysis in the test bulletin is the application of the power capacity of a locomotive to the working of service trains, and in this respect it is evident that a diesel-electric of 2000 h.p. nominal capacity is barely able to equal what is judged to be the maximum practicable performance of modern express passenger steam locomotives. This latter is not the "all-out" capacity, but the best that is generally considered feasible with present-day fuel. But the whole object of the modernisation plan is surely to improve services rather than maintain them at existing levels. If improvement is to be effected it seems evident that passenger locomotives of far greater capacity than any in the pilot scheme will be needed; a rating of 3000 h.p., rather than 2000 h.p., would seem to be nearer the mark, and in this respect the performance of the 3300 h.p. "Deltic" locomotive will be watched with particular interest.

HOME DEFENCE

Whatever the merits of the Government's defence proposals and the scheme of priorities, approved recently by Parliament, they give little encouragement to the nation to think about the defence of this country. There is indeed a growing disinclination to face up to realities, very similar to the attitude of mind which prevailed in the early thirties after Hitler came to power. It was felt at that time that war, which might well entail 100,000 civilian casualties within the first three weeks from strategical bombing attacks, had to be avoided at almost any cost, and conciliation and appeasement were the order of the day. Then, as now, the emphasis on British defence policy was on bombers and still more bombers. Though some reliance was placed on the Royal Navy and on the French Army to prevent complete disaster, the main hope of victory, in the unhappy event of a war, lay in a bomber counter offensive. Fortunately before strategical bombing started on the scale anticipated we were given time to make good to some extent our serious shortage of fighters and to organise plans for civil defence. To-day war is to be prevented not by appeasement, but by the ability to deliver the hydrogen bomb. There is, however, no essential difference in the picture presented to the British people. Despite their hatred of war in any form, they are continually reminded that war "would be a struggle for survival of the grimmest kind." Unofficial commentators, who claim to speak with authority, emphasise that half-a-dozen well placed hydrogen bombs would be the end of this country. The new weapon, like the bow and arrow or gunpowder in the past, is, it is alleged, decisive and has made war impracticable as an instrument of policy. Any suggestion that we should "fight on the beaches" or try and prevent those "half-a-dozen bombs" being well placed is dismissed as scarcely worth consideration.

Britain with her large towns and centres of industry concentrated in a few, relatively small areas, is without question extremely vulnerable. But until human nature changes it is surely the duty of a great nation to face up to the possibility of war with the determination to do everything possible to survive it. For the Western nations, the hydrogen bomb and the bomber which is to deliver it are weapons to be used only in retaliation and could not prevent the sudden and unexpected attack which would offer enormous advantages to an enemy. The priorities to be given to our Forces and our weapons are thus of particular importance for this country, with her limited resources, and require the personal interest of every thinking man and woman. Because of the Polar route, the Government and people of the United States are firmly convinced of the danger of an attack of this nature. Not only are hundreds of millions of dollars being spent on interceptor fighters and on ground-to-air and air-to-air guided missiles for home defence, but special attention is also being paid to the decentralisation of industry. Basically, industry in the United States is faced with defence problems similar to our own. Plants are placed in certain areas for economic reasons. None the less, the Office of Defence Mobilisation has recently issued a directive intimating that firms stand little chance of tax reductions unless new plants are built outside target areas. Failure to comply with the dispersal policy may, in fact, result in such penalties as refusal of defence contracts. Large firms are also being urged to build protective structures in plants now located in target areas. Though much remains to be done in this connection, these Government measures are undoubtedly meeting with some success, notably in getting firms away from the idea that "there is nothing much one can do about it." A number of large firms are now preparing over-all company plans embracing problems such as plant protection, alternative company headquarters, continuity of management and the continuation of production in the event of attack.

Not all these problems are applicable to this country, though the British Government, in deciding to build fourteen new towns, no doubt has in mind the decentralisation of industry as well as the depopulation of our larger cities. In any event the effects of "fall out" need not be regarded as unmanageable provided official instructions are complied with. If something can be done—as indeed it can—to prevent the accurate placing of large numbers of bombs, the goods produced in this country—supplemented by imports—might still enable us to survive. This, however, entails a heavy expenditure on fighters and guided missiles and on a Navy strong enough to deal with the Soviet Navy's thirty powerful cruisers and 500 submarines. It is indeed essential that the British people should take an interest in these and other no less urgent defence questions. Under modern conditions the £1,500 million which is available annually for defence is not a large sum. With the present need to provide for cold, limited and global wars, it is only too easy for the Government, unless it is carefully watched and criticised, to take the easiest course and encourage us to pursue our lawful occasions under the umbrella of the hydrogen bomb. "Provided the deterrent is maintained, the likelihood of global war has decreased" is a soothing mixture. But it is not necessarily a cure.

The Engineer

100 Years Ago

(MAY 30, 1856)

"A SUBJECT FOR A GOVERNMENT COMMISSION."

"It is a fact patent to all whose attention has been drawn to the subject, that the most destructive and fatal occurrences which attend the use of steam, namely, boiler explosions, are largely upon the increase. . . In such a state of things it is due to humanity that some great effort worthy of the scientific advancement of the age should be made to stay the giant evil. Such an effort we also think desirable if only for the credit of Science herself, as represented in the principal scientific men of the day—all of whom, if we do not err, have failed as yet to arrive at a definite scientific conclusion upon the subject.

"There are many causes assigned for explosions, and many others might be found in the opinions upon this point of the engineers of the day, yet, after all are stated, we are still without a knowledge of the true cause of these calamities. . . . But surely something could be done to correctly solve the problem; and to show those having the care of these engines—now mighty for evil as well as for good—that they are perfectly under their control; and also, to satisfy the non-scientific world that their lives are not jeopardised if they should venture within two hundred yards of a steam-boiler. Should steam-boiler explosions occur in the same number as they have recently occurred, a painful state of the public mind will certainly ensue; and the interference of Government will be loudly demanded.

"Before that period shall arrive, we would call upon the Government to institute a Commission composed of such men as Faraday, Stephenson, and Fairbairn, aided by clever, practical, working engineers. Let this Commission have placed at its command a boiler or a pair of boilers. Let those boilers be submitted to various temperatures with different sorts of firing. Safety valves of enlarged dimensions being used, the experiments could be carried on to an extent that would not place in peril the lives of the experimenters. If these experiments were carefully conducted, some clue might be found that would enlighten us as to the cause of boiler explosions, and they would point to the best mode of avoiding them."

A Seven Day Journal

First Calder Hall Reactor Becomes Self-Sustaining

WE learn from the United Kingdom Atomic Energy Authority that the first of the two reactors in the Calder Hall power station started operation last week. The Authority stated that "the first important step in the start-up of the Calder Hall power station took place late on Tuesday, May 22nd, when sufficient uranium had been loaded for the chain reaction to take place and for the first pile to become self-sustaining. Physics measurements and instrument checks are now taking place and the gradual commissioning of the plant will follow." The statement recalled that Her Majesty the Queen would officially open the station on October 17th, when for the first time "electricity on a large scale will be supplied from a nuclear power station to a national electricity network." Calder Hall is part of the Atomic Energy Authority's programme for power stations and is not included in the Central Electricity Authority's programme. The Atomic Energy Authority is also building a replica of the first Calder Hall station on the same site, and another station with four reactors at Chapel Cross, Annan, Dumfriesshire. These stations are designed for the dual purpose of producing electricity and making plutonium for the military programme. Another atomic power station at Dounreay, Caithness, will have an experimental fast breeder reactor. The first station, Calder Hall "A," houses two graphite-moderated, gas-cooled reactors, each of which produces plutonium and generates steam in four heat exchangers. There are four 23MW steam turbo-alternators in the turbine hall between the two reactors.

Electronic Developments

ON Thursday of last week, Sir Walter Puckey opened the new research and development laboratories of the Solartron Electronic Group at Goodwyns Place, Dorking, Surrey. Among the equipment demonstrated was a tactical radar simulator, able to produce on a tube surface the effect of up to twenty aircraft. Each aircraft can be given any true speed, rate of turn, and rate of climb, and can jam the plotting radar (obscuring its range), drop "window," or drop a jamming set by parachute. Various winds—constant at all altitudes—can be imposed, and altitudes are corrected for the curvature of the earth. The effects of different configurations of scanning aerials can be reproduced. The transfer function analyser, mentioned on page 501 of our issue of May 11th, was shown with a mechanical reference generator, enabling it to monitor machine elements in motion. An experimental device was seen "reading" printed digits; it scans the area of the symbol and observes whether black or white predominates in one hundred elements of area. The combinations of black and white appropriate to ten figures are stored in the machine, and the appropriate one selected; the speed of reading is of the order of hundreds of numbers per second. An intriguing exhibit included an electronic trainer; this can pose a question and provide full or incomplete guidance to the solution, allowing adequate or shorter times to answer. The amount of time and guidance are selected under the control of an information store recalling the answers, right, wrong or omitted, to previous questions. One presentation was a set of eight lights, one of which lit red to set the question, while the others progressively ceased to be yellow, the last to disappear being the answer; when correct solutions were being received the question would be withdrawn before the answer was defined. Any systematic error would result in the information needed to avoid that error being given prominence. Thus the trainer could inculcate in a human being a skill, the habit of offering a certain action consistently to a certain stimulus. The trainer, being able to learn, remember and decide, resembled in essentials a brain, and a corresponding unit, differing in that it possessed the faculty of information storage over a long period, had been built for it to instruct. This pupil, called Eucrates, was able to associate impulses that arrived together, and therefore its responses could be conditioned. When its brain was used to animate a toy dog, it was shown that the model responded even as the live animals in Pavlov's experiments on conditioned reflexes.

Iron and Steel Research

THE British Iron and Steel Research Association has published its report for 1955. It surveys the progress of work that is being done by the five divisions and by the operational research section. There is also included the general report of the council which records that at the end of last year the total membership of B.I.S.R.A. was 400. That figure, it is stated, includes seven of the principal steel-producing companies in Canada, Australia, South Africa, and India. The report goes on to say that last year the grant made by the British Iron and Steel Federation was increased to £450,000, and that, following discussion of the matter, the D.S.I.R. has offered an increase of £25,000 a year for 1956 and 1957 over the present block grant of £75,000, provided a minimum industrial income of £450,000 a year is raised. This offer has been accepted by the council; it will help, the report observes, to restore the liquid resources, which, by reason of past building commitments, had reached too low a level. In a reference to scientific manpower, the report mentions the work that is being done by B.I.S.R.A. in training and equipping the younger members of its staff for ultimate employment in the steel industry. In the last five years, forty-two members of the Association's technical staff have taken appointments in the steel industry and thirty-two have joined suppliers of the industry's capital equipment. The council says that it would like to see a greater interchange of personnel between the Association and the industry. It would welcome men from member-firms to undergo short-term training in the laboratories and to gain experience which would be to the mutual advantage of the member-firms and B.I.S.R.A. itself.

Kwinana Jetty

THE jetty built to serve the new oil refinery at Kwinana in Western Australia was discussed on Tuesday at the Institution of Civil Engineers, when a paper by Mr. P. Murray and Mr. D. N. Collett was before the meeting. The jetty is an open-piled, reinforced concrete structure, approximately "L"-shaped, with a shore arm about 800ft long and a "trunkway" about 1700ft long, from which stem three jetty heads each capable of handling a tanker of 32,000 tons. The constructional problems associated with the jetty showed much in common with some of the other large civil engineering structures which recent projects for new oil refineries have entailed, a principal point being the need for speed of construction. The authors considered that the Kwinana jetty had shown the great advantages which could be derived from a design mainly in precast concrete for a marine structure; two of these advantages were (*a*) the higher degree of control over all aspects of concreting which could be exercised in a casting yard, and (*b*) rapidity of construction with a corresponding reduction in hazard to floating craft. They considered that other outstanding features of the work had been: the large-scale application of prestressed joints for connecting the precast units; the flexible fendering system (a flexible face of 48ft was provided at each jetty head by eight fender units, each backed by a rubber block 22½in in diameter and 33in long); the value of radio communication on sea work; and the high degree of co-operation which was achieved. Kwinana jetty was built for the British Petroleum Company; the consultants were Messrs. Rendel, Palmer and Tritton, and the contractors, a consortium (Costain-John Brown, Ltd., D. and C. and William Press, Ltd.; and Kinnear Moody and Co., Ltd), known as the Kwinana Construction Group.

Fire Research in 1955

THE report of the Fire Research Board, which has just been published, records that during last year an agreement was made between the Department of Scientific and Industrial Research and the Fire Offices' Committee to increase the current and capital expenditure. It is therefore expected that the staff of the Joint Fire Research Organisation will be increased from under eighty to over one hundred. Among the background research inquiries mentioned is the development at Imperial College of a technique of investigating the characteristics of a flame by observing the effect on a narrow, oblique beam of light. The Fire Research Station has made a study of the incidence of vehicle fires; commercial and public service vehicles, at 0·2 per cent per year, were about double car and motor cycle incidents, and causes included overheating of differentials and under-inflation of tyres. However, 3 per cent per year of electric vehicles suffered fires. Spontaneous ignition, both of solid and fragmented wood, was studied, and instruments to assess the fire or explosion risk associated with combustible vapours are being examined. Experiments with chlorobromomethane on petrol fires disclosed a great advantage in applying the agent in the form of a flat spray. These fires were attacked down wind, and the ability of the fan spray to cover the whole width of the fire seemed to be important. Similar flat sprays were used to apply powdered sodium bicarbonate to petrol fires, and it was shown that the total surface area of powder applied is the governing factor in extinction. The investigation of the effects of heat on concrete continued, and experiments on the ignition of different roofs under incident radiation were performed. The size of flaming coal particle needed to light certain domestic materials was determined in order to judge the effectiveness of fire guards. Bearing in mind the hazardous atmosphere existing in operations such as aircraft refuelling, static electricity generated on clothing materials was tested; materials such as wool gave 10,000 times higher energy levels than cotton.

Performance of 2000 H.P. Main-Line Diesel-Electric Locomotive

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. II—(*Concluded from page 553, May 25th*)

In THE ENGINEER *for October 2, 1953, the author commented upon a test bulletin dealing with one of the 1750 h.p. diesel-electric locomotives ordered by the former Southern Railway for main line service between Waterloo and the West of England. In dealing with the larger locomotive No. 10203 the test bulletin published by the British Transport Commission interprets the results in terms of timetable planning. In a previous article the author commented upon the methods of test and the relations obtained; in this concluding article their application is discussed.*

THE Bulletin includes very complete details of the runs made with service trains, the 1 p.m. Waterloo to Exeter Central, and the 5.55 p.m. Exeter Central to Waterloo. Summarised results are given in the accompanying table of a typical run on the 1 p.m. down. On this particular duty the load is reduced at Templecombe, and data is given in Table I for :

(a) Waterloo to Exeter overall.
(b) Waterloo to Templecombe.
(c) Templecombe to Exeter.

In the Bulletin an alternative sub-division is given for each run, with a dividing point at Salisbury where the engine is re-manned ; there is a further point in making Salisbury a division point for the analysing of test results, in that the physical character of road changes there from one of relatively gradual gradients to a saw-tooth profile. But it should be noted that on all runs made, however sub-analysed, the tractive efficiency, when related to the ratio between trailing weight and total load, remained remarkably constant, between a minimum value of 26·4 per cent and a maximum of 27·8 per cent.

These may be compared with the average results of the controlled road tests shown in Table II. The 1 p.m. express from Waterloo, especially with the loads of thirteen and fourteen coaches conveyed on two of the test trips, is a severe duty, involving a considerable amount of full power working ; this, of course, is favourable to the diesel, and enabled the excellent overall traction efficiencies of approximately 20 per cent to be achieved. On service runs with the same two trains, on occasions for which the author has very complete details of the working, the following overall results were obtained :

	Waterloo–Templecombe	Templecombe–Exeter
Load and number of vehicles	365 (11)	301 (9)
Ratio, trailing load/total weight	0·73	0·695
Running time :		
Booked, min	129	74
Actual, min	123½	63½

On this run not only was there a substantial gain on booked time, with an arrival 5½ minutes early in Exeter, but the effects of three permanent way checks are included —a total loss in running of 13 minutes. The net gain to locomotive over the whole run from Waterloo to Exeter was therefore 27 minutes on this particular journey. The locomotive was being worked hard for most of the journey, with the motor current well in excess of 1000 amperes ; but it is evident if the road had been clear throughout, and strict point-to-point timings maintained, the effort demanded from the locomotive would, with these loads, have been considerably less.

TABLE II—*Average Results of Controlled Road Tests*

Route : Lines 1, 3, 5 and 7 Exeter to Salisbury
Lines 2, 4, 6 and 8 Salisbury to Exeter

Column No.	1	2	3	4	5	6	7	8
Line	Date	Load, tons	*l*/*k*	Traction d.b.h.p. hours	Fuel used under power, lb	Fuel per traction d.b.h.p. hour, lb	Traction efficiency, per cent	Traction efficiency × *l*/*k*, per cent
1	June 28, 1955	392	1·339	1436	983	0·685	19·12	25·60
2	June 28, 1955	392	1·339	1324	894	0·675*	19·40	25·95
3	June 29, 1955	286	1·466	972	701	0·721	18·17	26·60
4	June 29, 1955	286	1·466	975	690	0·708*	18·50	27·10
5	June 30, 1955	130	2·025	483	462	0·957	13·68	27·70
6	June 30, 1955	130	2·025	460	442	0·962*	13·60	27·55
7	July 1, 1955	63	3·113	184	285	1·550	8·45	26·30
8	July 1, 1955	63	3·113	212	326	1·538*	8·52	26·50

l/*k* = weight of trailing load/total weight.

By intent the working in tests shown by lines 1 and 2, and 7 and 8 was outside the band of maximum traction efficiency and in those shown by lines 3 and 4, and 5 and 6 within the band of maximum traction efficiency.

TABLE I—*Summarised Results of Tests on Revenue Earning Trains*

Down trains : 1.00 p.m. ex Waterloo to Exeter Central, stopping at Woking, Andover Junction, Salisbury, Templecombe, Sherborne and Yeovil Junction

A—Waterloo–Exeter overall
B—Waterloo–Templecombe Section
C—Templecombe–Exeter Section

		July 5, 1955		
		A	B	C
Line	Column No.	1	2	3
	Load and number of vehicles :			
1	Waterloo to Templecombe, tons tare	425 (13)	425 (13)	—
2	Templecombe to Exeter tons tare	329 (10)	—	329 (10)
	Distance :			
3	Actual, miles	171·4	112	59·4
4	Under power, miles	139·9	99·4	40·5
5	Ton-miles (tare weight of trailing load)	67,140	47,600	19,540
	Time :			
	Booked :			
6	Overall, min	221	139†	79†
7	Running, min	203	129	74
	Actual :			
8	Overall, min	217·3	139·5†	75·3†
9	Running, min	194·9	126·3	68·6
10	Standing at stations min	22·4	13·2†	6·7†
11	Under power, min	157·3	108·8	48·5
12	Drifting and braking, min	37·6	17·5	20·1
	Average speed :			
13	On running time m.p.h.	52·8	53·1	51·9
14	Under power, m.p.h.	53·4	54·8	50·1
15	Work done, traction b.h.p. hours	2,433	1,807·5	625·5
16	Average traction d.b.h.p.	928	996	758
17	Average traction d.b.t.e., tons	2·91	3·04	2·59
	Oil :			
18	Gross calorific value, B.Th.U./lb	19,340	19,340	19,340
19	Total used, lb	1,618	1,180*	436*
20	Used under power, lb	1,574	1,157	417
21	Average rate under power, lb/hr	601	639	516
22	Used while standing at stations, lb	16	9*	5*
23	Average rate while standing at stations, lb/hr	42·9	40·9	44·8
24	Used while drifting and braking, lb	28	14	14
25	Average rate while drifting and braking, lb/hr	44·7	48·0	41·8
26	Lb/traction d.b.h.p. hour on total fuel used	0·665	0·653	0·698
27	Lb/traction d.b.h.p. hour under power	0·648	0·640	0·667
28	Lb/mile on total fuel used	9·44	10·53	7·35
29	Lb/mile under power	11·25	11·63	10·30
30	Lb/ton-mile on total fuel used	0·0241	0·0248	0·0223
31	Lb/ton-mile on fuel used while running	0·0239	0·0246	0·0220
32	$\frac{\text{Energy transmitted to trailing load} \times 100}{\text{Energy in total fuel}}$, per cent	19·8	20·1	18·9
33	$\frac{\text{Energy transmitted to trailing load} \times 100}{\text{Energy in fuel used under power}}$, traction efficiency, per cent	20·3	20·6	19·8
34	$\frac{\text{Traction efficiency}}{k}$, per cent	—	27·0	27·8

The term "under power" refers to periods when power generated by the power unit is being transmitted to the trailing load. The terms "traction d.b.h.p. hr" and "traction d.b.t.e." refer to power and tractive effort transmitted to the trailing load as measured by the dynamometer car.

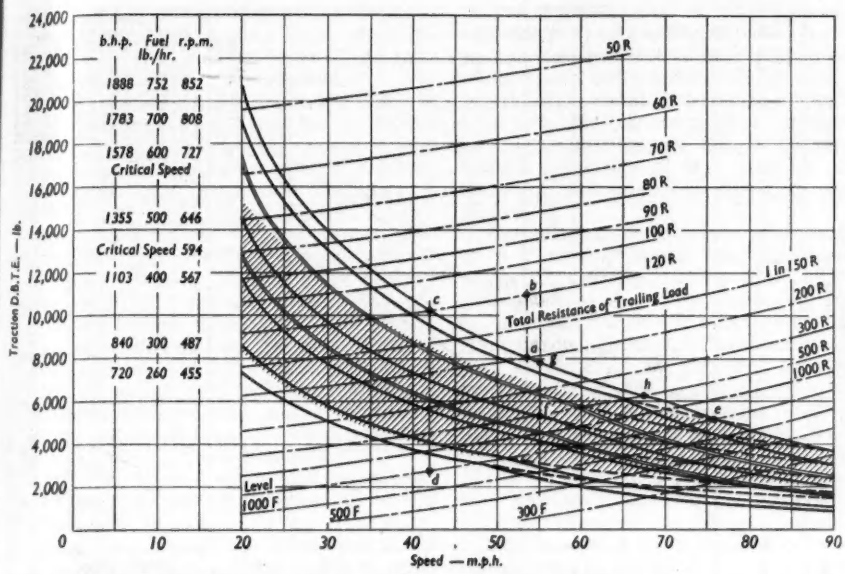
* Excludes fuel used while standing at Templecombe Station.
† Excludes time standing at Templecombe Station.

$k = \frac{\text{Weight of trailing load.}}{\text{Total weight}}$

THE TIME SCHEDULE AND THE COMMERCIAL COST OF ENERGY

From the controlled road tests, and the principal relations derived therefrom, a number of diagrams have been prepared and included in the bulletin showing the performance and traction efficiency with passenger trains of varying weights, related to level road, and the full range of gradients experienced in running. The diagram for a 400-ton train is reproduced herewith, Fig. 12. This diagram has been "hatched," to show the range of working rates for which the traction efficiency is within 2 per cent of the maximum. It is now a question of applying this data to the economical scheduling of trains.

The controlled road tests showed that the locomotive is capable of making mechanical energy available at a substantially constant efficiency no matter where in the service range the locomotive may be worked. It is capable of transmitting mechanical energy for haulage of the trailing load at an efficiency proportional to the trailing/gross weight ratio. The commercial cost of energy is affected not only by these factors, but also by the economy with which mechanical energy is used ; it is also a function of the average speed of displacement, as well as of the load displaced. The use of the locomotive on duties commensurate with its power is bounded on the one hand by capacity, which can be precisely defined, on the other hand by the small



Traction Efficiency is the energy transmitted to the trailing load as a percentage of the energy in the fuel. The hatched band covers all rates of working for which traction efficiency is within 2 per cent of the maximum.

Fig. 12—Performance and traction efficiency, 400 tons passenger train

return on the annual capital cost of the locomotive hour. Between the two limits lies the operating range within which the duties may be freely chosen having regard to allowances which, from local experience, must be made for correcting minor breaches of the timetable and delays due to permanent way repairs.

The problem is how to translate all the performance and efficiency relations which have been extracted from the results of the Controlled Road Tests, and all the observations which have been made on revenue earning trains in respect of the conservation of mechanical energy, into the ordinary non-technical terms required for the construction of the timetable in respect of the minimum commercial cost of energy ; how to display clearly and simply the range of duties offered to the operating and commercial departments in a way which presents the implications of the choice without restricting it. But while the availability of mechanical energy and efficiency with which it can be supplied can be presented in a few simple relations there is no such short cut for dealing with the cost of energy. The fly-wheel effect of the mass of the train, the track features of the route, the restoration of kinetic energy following destruction by braking so affect the cost of energy that each route must be treated individually.

Cost of Energy Diagram

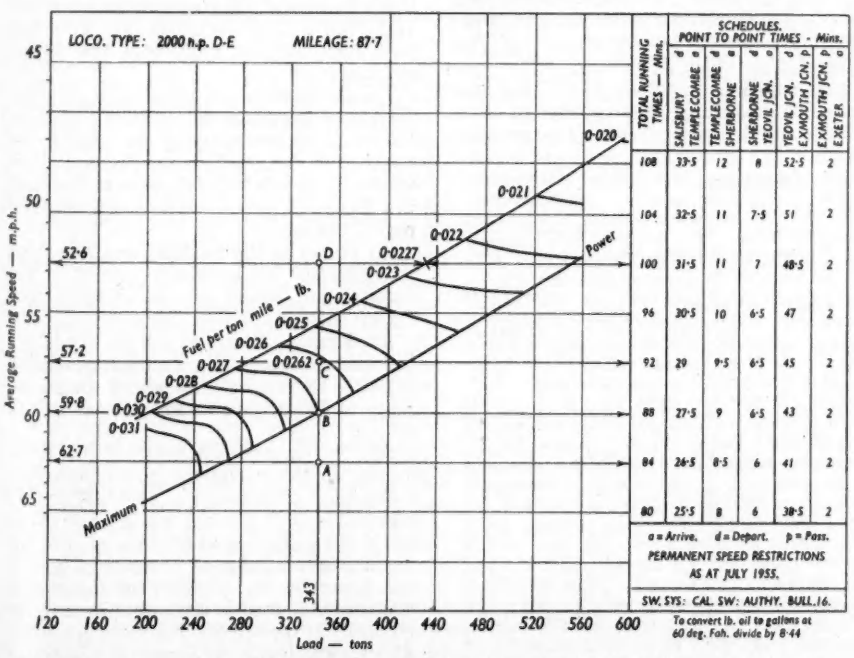
The principle of the analysis can be explained by reference to a particular route and service, that from Salisbury to Exeter, Southern Region, and a typical diagram is shown in Fig. 13. The base of the diagram is load in tons and the vertical scale, marked off on the right-hand border, is total running time. A non-linear scale on the left enables total running time to be related to the average running speed by horizontal projection. This is useful in showing the influence of speed on fuel consumption.

Suppose it is desired to run a service at an overall running time of 84 minutes with a load of 343 tons : a line drawn vertically upwards from 343 tons on the base to meet a horizontal from 84 minutes on the time scale locates the point *A*. This point is seen to lie below the diagonal marked "maximum power," which signifies that such a service is beyond the capabilities of the locomotive. Increasing the time to 88 minutes, with the same load, locates the point *B* on the maximum power line. This means that if there are no temporary speed restrictions and no other checks this service could be worked by the locomotive by using full power wherever possible and practicable, strictly observing all permanent speed restrictions. The schedule corresponding to the maximum conservation of mechanical energy is that set out alongside the total running time of 88 minutes. All point-to-point times have been rounded off to the half-minute, as this is the minimum practical time period for scheduling. The fuel consumption indicated by *B* is seen to be 0·027 lb per ton mile. Total running fuel consumption is, therefore, not likely to be less than $0{\cdot}027 \times 343 \times 87{\cdot}7 = 813$ lb, or 96·3 gallons. But it is extremely likely that the time-keeping reputation of this service would prove unsatisfactory, as there is no margin for countering minor breaches of the timetable and repairs to the permanent way.

A proposal to increase the overall running time to 92 minutes may next be examined, the load remaining as before. This is indicated by the point *C*. The schedule of the train which corresponds to the maximum conservation of mechanical energy is that written against the new time. It is clear that the locomotive now has a nominal time margin of 4 minutes with the given load. The fuel consumption shown by *C* is 0·0262 lb per ton mile with no delays, but may be as high as given by *B* at the intersection of the load line with the maximum power line in adverse circumstances. Hence, total running fuel consumption is not likely to be less than $0{\cdot}0262 \times 343 \times 87{\cdot}7 = 788$ lb, or 93·5 gallons, nor more than the 96·3 gallons indicated by *B*.

Another proposal, which illustrates points of practical importance, is that of increasing the overall running time to 100 minutes for the same load. This is denoted by point *D*. Since *D* lies above the upper diagonal of the diagram, its fuel consumption for the schedule given, in good operating conditions, is read at the intersection of the horizontal through the point with the upper diagonal, which is at 0·0227 lb per ton mile. If intermediate stops are infrequent and the recommended point-to-point timings are accepted, *D* represents a generous margin of 12 minutes. It is unlikely that the whole of this margin would then be required, and the maximum probable fuel consumption may well be taken at the more practical margin indicated by *C*, 0·0262 lb per ton mile. Hence, total running fuel consumption is unlikely to be less than $0{\cdot}0227 \times 343 \times 87{\cdot}7 = 663$ lb (78·7 gallons) nor more than 788 lb (93·5 gallons). In these circumstances the booked (recommended) schedule is an easy one ; it is so far removed from the full power schedule for the load that the point-to-point times are capable of some modification within the overall time, but any such modification is done at the expense of increasing the mechanical energy required and consequently fuel consumption.

Even so, the economical running of an easy schedule depends ultimately on the handling of the locomotive. The tests clearly demonstrated that when drivers avoided light fuel rates and worked the locomotive in these circumstances by alternating periods of high power and drifting, taking every



British Railways—Southern Region Salisbury-Exeter passenger services, calling at Templecombe, Sherborne and Yeovil Junction.

Fig. 13—Cost of energy and performance

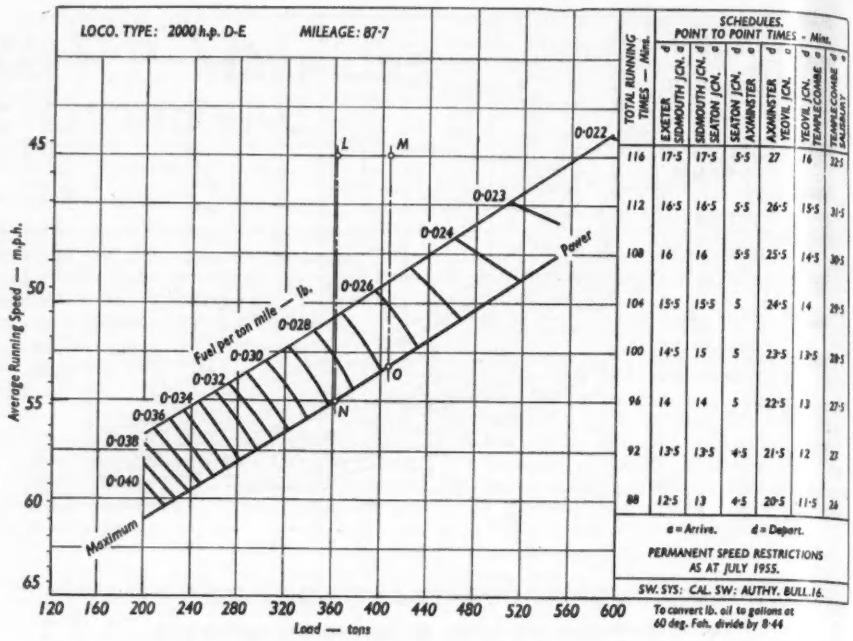
advantage offered by the gradient profile, total fuel consumptions were significantly less than those resulting from more regularly applied light fuel rates, which agrees with theoretical findings. This produces a discontinuity in the curves of fuel per ton mile, roughly indicated by the upper diagonal.

Booked, Recommended and Actual Times

On the basis of the cost of energy diagram it is interesting to compare the booked times and those actually run with times that could be recommended as a result of an analysis such as that demonstrated in Fig. 13. It is now applied, as in Fig. 14 to the up road, to a service calling intermediately at Sidmouth Junction, Seaton Junction, Axminster, Yeovil, and Templecombe, and booked in an overall running time of 116 minutes. Table III compares the booked and recommended timings and also sets out the actual times made on two runs with dynamometer car on July 4th and July 6, 1955, together with a third run made in ordinary service on the same train, some two months before the date of the special trial runs of July.

On the two test journeys the economy in overall time from Exeter to Salisbury, including time at intermediate stations, was 3½ minutes and 4¼ minutes respectively, while on the service run in May, 1955, the train left Exeter 8¼ minutes late and was on time by Templecombe. Upon reference, once again, to Fig. 14 it will be seen that for a timing of 116 minutes a load of no more than 299 tons is an extremely easy one ; though the clear gain of nearly 18 minutes on schedule, giving a total running time of 98 minutes, brings the actual performance within the band covering rates of working for which the traction efficiency is within 2 per cent of the maximum. The cost of the checks experienced on this run are estimated at 4 minutes; this, having an equivalent net running time of 94 minutes, represents something very near to maximum power.

Regarding the work with the heavier loads of the test trains, and the subject of driving technique the Bulletin comments : " Though mechanical energy can be made available by the locomotive at a substantially constant efficiency right down to low power demands, it is the economic use of mechanical energy which predominates on the easy schedule ; this is then achieved by working wherever possible in the higher powers interspersed with periods of drifting, taking every advantage offered by the gradient profile. In general it was found that drivers had a highly developed sense of conservation of mechanical energy, but their efforts were restricted on occasions by sectional timings which were unrelated to the economic use of mechanical energy ; fuel consumption was then higher than need be in consequence. But where they were free to exercise their skill the speed-distance curves produced conformed almost exactly with those which form the basis of the recommended schedules in the diagrams."


LOCO. TYPE: 2000 h.p. D-E
MILEAGE: 87·7
Average Running Speed — m.p.h.
Load — tons
Fuel per ton mile — lb.
Maximum
Power
L
M
N
O
TOTAL RUNNING TIMES — Mins.
SCHEDULES. POINT TO POINT TIMES - Mins.
EXETER SIDMOUTH JCN.
SIDMOUTH JCN. SEATON JCN.
SEATON JCN. AXMINSTER
AXMINSTER YEOVIL JCN.
YEOVIL JCN. TEMPLE COMBE
TEMPLE COMBE SALISBURY
116 17·5 17·5 5·5 27 16 32·5
112 16·5 16·5 5·5 26·5 15·5 31·5
108 16 16 5·5 25·5 14·5 30·5
104 15·5 15·5 5 24·5 14 29·5
100 14·5 15 5 23·5 13·5 28·5
96 14 14 5 22·5 13 27·5
92 13·5 13·5 4·5 21·5 12 27
88 12·5 13 4·5 20·5 11·5 26
a = Arrive. d = Depart.
PERMANENT SPEED RESTRICTIONS AS AT JULY 1955.
SW. SYS: CAL. SW: AUTHY. BULL. 16.
To convert lb. oil to gallons at 60 deg. Fah. divide by 8·44

British Railways—Southern Region Exeter-Salisbury passenger services, calling at Sidmouth Junction, Seaton Junction, Axminster, Yeovil and Templecombe.

Fig. 14—Cost of energy and performance

The highly developed sense of conservation of mechanical energy referred to in the above quotation from the Bulletin finds notable confirmation in the details of runs made in May, 1955, two months before the date of the trials. As one might expect from the overall result, full power was being used between Exeter and Salisbury for all the uphill and fast work, with the controller shut off altogether, or eased back to a drifting position on all the steep descending gradients that characterise that route. Out of the total running time of 98 minutes full power was used for approximately 64 minutes—a high proportion, seeing that the time of braking for five intermediate stops is included in the total of 98 minutes, in addition to the time spent coasting or drifting on favourable gradients. While agreeing generally with the comments of the Bulletin upon the skilled enginemanship of the drivers handling the diesel locomotive, anyone familiar with the traditions of steam locomotive running over the Salisbury-Exeter route would remark upon the similarity of the running characteristics, as represented by the time-speed curve, displayed by both forms of power. Broadly speaking, the diesel was not run at quite such high maximum speeds as are often obtained downhill, though with comparable loads the Bulleid " Pacifics " of the " West Country " class, not to mention the larger " Merchant Navy " class, frequently display equally fast climbing on the banks.

Table III—5.55 *p.m. Exeter Central to Salisbury*

Diesel-electric locomotive No. 10203

	Miles	Point to point timings : min				
		Recommended (Fig. 13)	Booked	Actual runs in 1955		
				July 4th	July 6th	May
				362·5 tons	407·5 tons	299 tons
Exeter ... ... dep.	12·1	17½	18	15	15	14·3
Sidmouth Junction ... ... arr. dep.	11·5	17½	16	15·4	15·8	14
Seaton Junction ... ... arr. dep.	3·3	5½	5	4·8	4·8	5*
Axminster ... ... arr. dep.	21·9	27	28	26·5	29·1*	22·1
Yeovil Junction ... ... arr. dep.	10·6	16	16	13·8	15·4	13
Templecombe ... ... arr. dep.	28·3	32½	33	31·9*	30·8	29*
Salisbury ... ... arr.						
Time gained by engine, min ...	—	—	—	8·4	5·1	17·6
Total time, min	—	116	116	116	116	116

* Includes time lost by temporary speed restriction.

Conclusions

From a study of the test results a number of the conclusions drawn in the Bulletin may be particularly quoted :—

(1) The diesel engine had fallen 4 per cent in efficiency and 3 per cent in power at full load after completion of 106,000 miles and 2865 hours without more than the normal servicing.

The fall in power is based upon the comparison of the maximum measured b.h.p. of 1888 with the lower limit of the initial power setting, 1950 b.h.p., since it is the lower limit which is operable during acceleration and near balancing speeds that provided the major part of the test data.

(2) Losses in the auxiliary generator and provision for all auxiliaries, including the radiator fan, under average running conditions account for some 105 engine b.h.p.

(3) Between 20 m.p.h. and 90 m.p.h. the inclusive efficiency of the electric transmission is nearly 83 per cent throughout the service range of 38 per cent to 100 per cent of full output.

(4) The thermal efficiency of the diesel engine at the maximum power measured (1888 b.h.p.) was found to be 32·4 per cent which falls to 30·6 per cent when referred to the power remaining when absorption by the auxiliaries is deducted ; multiplying this last figure by the efficiency of the electric transmission gives a representative average efficiency at the rail of 25·5 per cent, a figure also reached under passenger service conditions. It was demonstrated that this value

does not fall at part load ratings down to 38 per cent of full output ; in fact the value rises to 27 per cent at intermediate part load ratings under service conditions.

(5) A tractive effort at the rail of 28,600 lb was produced at 19 m.p.h. at the continuous rating of the electrical equipment. This compares with the designed effort of 29,000 lb obtainable with the current limitation of 1700A. At higher speeds the rail tractive effort characteristics at full power substantially agree with the designed characteristics. During accelerations between 0 m.p.h. and 20 m.p.h. a mean effort at the rail of 32,800 lb may be assumed under general current limitations ; to this corresponds a mean fuel rate of 450 lb per hour.

(6) The two specified continuous ratings for the generator have been shown to provide for all the possibilities of service operation and to cover the tractive motors.

(7) The speed-distance and speed-time relations and fuel consumption in normal service were found to be in very close agreement with those which may be calculated from the specific resistance of the coaching stock and either the rail tractive effort and track and wind resistance of the locomotive or the equivalent drawbar tractive effort or the traction drawbar tractive effort/trailing: gross weight ratio characteristic, all as given in this Bulletin. Similarly the drifting characteristics in normal service may be represented by those which may be calculated from the specific resistance of the coaching stock and track and wind resistance of the locomotive.

The bulletin contains an interesting example of a "cost of energy and performance diagram" calculated for a route entirely different from that over which the actual trials of locomotive No. 10203 were conducted. It is, of course, no more than natural that the Swindon experimental and locomotive testing station might apply the testing results to examine the possibilities of the locomotive on a Western region route, and the principles embodied in the diagrams, Figs. 13 and 14, are applied to the haulage of non-stop expresses between Paddington and Newton Abbot. The results are of particular interest in view of the heavy load trials also carried out in 1955 with steam express passenger locomotives of Class 8 capacity.

British Electrical Power Convention

The eighth British Electrical Power Convention was held in Torquay from May 23rd to 29th. In his presidential address on May 24th, Sir John Dalton introduced the theme of the convention, "Electricity and Transport." The major part of his address (abstracts of which are printed here) dealt with the new railway electrification plans and their impact on the electricity supply and manufacturing industries.

The New Electrification Plans

TRANSPORT, as a whole, must be about the largest employing industry of the nation, with an employment total which amounts to some 6 per cent of the working population. In other words, the transport industry employs some 1½ million persons engaged directly in public transport. We are mainly concerned, however, with the position of British Railways, who are the largest employers in this vast number of the population engaged in transport with some 40 per cent of the total, viz. 577,000 employees.

British Railways, if we exclude shipping, carries some 63 per cent of the total traffic of the country and earns some 25 per cent of the total revenue, i.e. £448 million. We know that our railways have been operating under severe financial difficulties carrying a very substantial percentage of the total traffic at low load factors in equipment which is out-of-date. Therefore we are bound to welcome this imaginative modernisation scheme by our transport colleagues in the almost certainty that their new capital investment will overcome much of their financial difficulties. To the public in general the scheme will enable faster, regular and more frequent railway services. To industry with freight traffic moving at express speeds there must be important beneficial reactions and possibly an alleviation of the appalling state of our present heavy freight road traffic. However, we electrical people are bound to consider the incidence of this electrification plan on our own industry, both from the viewpoint of supply and manufacture. I would like first to consider the implications of the estimate that has been made of increased consumption by the British Transport Commission when the new proposals are complete in fifteen years' time. The increase in annual consumption is estimated at approximately 1,500 million units per annum. This appears, at first sight, to be a very useful contribution to our national output, particularly as a considerable proportion of the consumption will occur during the night, as the predominant traffic on the railways will be freight traffic and this will be mostly moved at night on the main trunk routes.

It would be wrong of me to say that the load now on offer from the railways is insignificant in comparison with our national output. It would, however, be true to say that the present electrification plan—excellent and imaginative as it is—is unlikely to have any material effect on the national daily load curve. Let us not forget, however, that this plan is the first instalment of true main line electrification, and I venture to state that the impetus which this instalment will provide should—and, I feel, must—bring much closer the more general electrification of our main line railways than is contemplated to-day by the present scheme. The complete substitution of steam haulage by electricity, wherever justified economically, must be the goal.

In 1931, the time of the Weir Report, the prospective total annual consumption of the British Transport Commission would have represented some 30 per cent of the annual output of the supply industry ; by 1960, however, this percentage has fallen to 3½ per cent and is likely to drop to 2½ per cent by 1971. The estimated increase in consumption of electricity for traction purposes only expected by 1971 as a result of the newly-announced electrification plans would have been 12½ per cent in 1931, but by 1971 it is likely to amount to only 1 per cent.

It is obvious, therefore, that even on the assumption that a considerable proportion of the demand will be met during the night hours, the effect on the national daily load curve is unlikely to be material. It is possible, of course, that as the load will not be spread evenly over the whole country, but through the twelve proposed 132kV/25kV transforming stations, there will result benefit more particularly to those generating divisions that lie nearest to the transformers.

It is of interest to consider how these figures compare with those of other countries. According to information supplied by U.N.I.P.E.D.E. (Union Internationale des Producteurs et Distributeurs D'Energie Electrique) for the ten-year period from 1939–1949, the highest proportion of traction consumption of electricity to total consumption was achieved in Sweden, where the proportion was maintained at 9 per cent despite the fact that the total consumption was very nearly doubled during that time. Only in the U.S.A. and the Netherlands, in addition to Great Britain, did the traction percentage fall during the period. There is very little doubt that at the present time the proportion of electricity consumed for purely traction purposes is probably lowest in Great Britain by comparison with most European countries.

Turning now to the comparison of the prospective traction consumption with other loads, Table I may be of some interest. In this you will find estimates of some domestic loads compared with the estimated increase in annual consumption which occur as a result of the British Transport Commission fifteen-year electrification plans. The figures in the table are very approximate and are based on certain assumptions which I realise are open to criticism. Nevertheless, I feel that they do serve to give some comparison of the position. The assumptions I have made are that 8,500,000 radio sets consume an average of 60kWh each per annum ; that 5,500,000 television sets consume an average of 180kWh each per annum, that 3,250,000 cookers consume an average of 1400kWh each per annum. To estimate space heating consumption, I have assumed 6,500,000 consumers requiring an average of 1000kWh per annum each. The figure for domestic water heating has been deduced by subtracting these amounts, together with other known domestic loads, from the total annual domestic consumption.

From the table we draw the surprising conclusion that, extensive as the new plans are, the increase in railway traction consumption will be about equal to that accounted for at the present time by the radio and television loads.

TABLE I—*Comparison of the Present Domestic Loads with the Expected Increase in Traction Loads.*

Type of load	Million kWh per annum
Domestic space heating	6500
Cookers	4550
Domestic water heating	2500
Traction (expected increase in load due to new electrification scheme)	1500
Television	990
Radio	510

Nothing which I have tried to illustrate in the foregoing figures is intended to detract from the benefits to the Supply Industry which must flow from the railway plan. The railway demand must favourably affect the national load factor. We know from experience that, once electrification starts, the demand becomes such that it must go on developing.

Export Considerations

Let us turn now to the incidence of the railway plan on the manufacturing side of our industry.

Fortunately, to-day, the manufacturers can meet the many problems involved in railway electrification with confidence. Transformers and circuit breakers are already fully developed for industrial purposes, using the standard frequency, and can readily be adapted for rail traction. British made d.c. traction motors cannot be excelled anywhere in the world. Germanium rectifiers for traction are already on trial on the Lancaster-Heysham Line and good progress is being made.

What might be the impact of the railway plan on our export trade for traction purposes ?

There is every reason to suppose that within the next year the official trade returns will show the electrical manufactures of this country as constituting the largest export group in the United Kingdom. This is all the more significant because, as an industry, we were lying fifth in the same system of grouping in 1939. In 1939, the gross value of exports from the U.K. was approximately £440 million and the total electrical exports accounted for £19,200,000 i.e. some 4·3 per cent. In 1955, while the gross value of exports had risen to £2905 million, the total electrical exports had risen to £245 million, and this represents some 8·4 per cent of the total.

However, from curves [not reproduced here] it is evident that no real progress has been made in the development of export business of pure electric drive for railway purposes. Apart from diesel-electric exports, less than 1 per cent of the total electrical export business was accounted for by traction items. There is, to my mind, very little doubt that the failure of our traction export business to keep pace with the overall growth of electrical exports is due, in part at least, to the fact that we have been unable in this country to show foreign and Commonwealth visitors effective electrification schemes,

particularly on trunk lines operating in the U.K. The decision of the British Transport Commission in their present modernisation plans which are up-to-date and applicable to the needs of most other countries is, therefore, to be welcomed by the manufacturing industry, as it provides at last the possibility of our having an effective international showcase.

Capital Investment

I turn now from transport to one of our recurring post-war problems, that is, the restriction of capital investment placed primarily on the Central Electricity Authority but which must reflect itself on the whole economy of our industry.

The degree of the restriction has been mentioned in Parliament to the effect that the figures of capital investment (i.e. in fixed assets) by the Central Electricity Authority and the Area Boards during the financial year 1956/57 are :—

"Normal" programme	£213 million.
Reduced programme as submitted by the Authority to Government	£204 million.
Programme as finally approved by the Government	£195 million.

Thus, there is a reduction of £18,000,000 in the investment as originally planned which is to be shared in roughly equal proportions between "generation" and "distribution."

What is the effect of this decision on our industry? First, whilst it cannot affect the generation construction programme for the plant to be commissioned this year or next because work on the stations is already well-advanced and could not be stopped without wasteful consequences and serious financial disturbances; but, for 1958 and 1959, the capacity of the plant which the Central Electricity Authority had originally planned to commission will be reduced, it is estimated, by some 500MW. Secondly, this holding-up of capital works may have more serious effects than the estimated short fall of commissioning in 1958/59. From the manufacturers' point of view, interference with balanced and carefully phased programmes must result in a loss of impetus and rhythm and the postponement of delivery dates for large orders must to come extent disorganise production in the shops. Thirdly, the restriction must have a serious effect on the distribution programme of the Area Boards. For some years now, the Boards have been tackling the two-fold problem of (*a*) undertaking the backlog of reinforcement work remaining from the war and immediate post-war years, and (*b*) at the same time endeavouring to cope with rapidly increasing demands for new supplies.

The present restriction must put back the day when the Central Electricity Authority could have met in full all demands at peak periods without danger of load shedding or voltage reduction. The Economic Survey for 1956 states that at the time of maximum simultaneous demand on the supply system during the past winter, potential demand was restricted by nearly 1,000,000kW. through the reduction of frequency and voltage below the standard levels.

I am bound to make reference to the fact that, on top of the restrictions already imposed on the industry by way of capital investment, there are some new borrowing arrangements for the nationalised industries which, I think, are to be operative for a period of two years. The Government have taken power to provide for the long-term borrowing for the Central Electricity Authority and other nationalised industries from Exchequer moneys. It is obvious that this new arrangement must enable the Government, if they so wish, to strengthen their control over the investment programme of the Central Electricity Authority. If, indeed, this additional "physical control" on the supply industry indicates in any way a handy means of imposing further restrictions on capital investment, it is something to be deplored. It would mean, it seems to me, that the Central Electricity Authority would have to provide more of their funds from internal savings which, in turn, means charging the consumer more for his electricity. In this case it is an odd method of enforcing compulsory saving.

In my view, the railway electrification plan which brings welcome contracts to our manufacturing industry, does not render nugatory the effects of these restrictions on capital investment. The annual output of the manufacturing industry, excluding telecommunications and radio, is of the order of £650 million and the fifteen-year spread of the railway equipment orders, the work for which will fall on a comparatively small section of the industry, can be absorbed quite comfortably.

Five papers on electricity and transport were presented and discussed on Friday, May 25th, as follows : "Electricity in Rail Transportation," by S. B. Warder, British Transport Commission ; "Electricity Supply and the Railway Load," by F. J. Lane and W. B. Noddings, Central Electricity Authority ; "Electricity in Locomotives," by C. M. Cock, English Electric Company, Ltd. ; "Electric Multiple Unit Trains and Equipment," by F. A. Manley, General Electric Company, Ltd. ; and "Electric Signalling Systems for Rail and Road Transport," by D. G. Shipp, Westinghouse Brake and Signal Company, Ltd.

On Saturday, May 26th, two papers were presented for discussion : "Railway Electrification in the Commonwealth," by E. L. E. Wheatcroft and H. H. C. Barton, of Messrs. Merz and McLellan ; and "Substation Equipment for Road and Rail Systems," by G. S. Causon and F. G. Stevens, Hackbridge and Hewittic Electric Company, Ltd.

The proceedings continued on Monday, when a paper, "The Domestic Consumer," was presented (with demonstrations) on behalf of the British Electrical Development Association by D. Bellamy, Yorkshire Electricity Board. There followed two papers : "Electric Passenger Road Vehicles," by J. H. Cansdale, British Thomson-Houston Company, Ltd., and "Battery Electric Vehicles," by W. H. Heyman, Smiths Delivery Vehicles, Ltd., P. Rochs, Austin Crompton Parkinson Electric Vehicles, Ltd., and R. H. Simpson, T. H. Lewis, Ltd.

The convention closed on Tuesday, May 29th, with the "Electrical Forum," followed by the annual general meeting.

British Main Line Electrification at 50 c/s

The first of the five papers presented for discussion at the British Electrical Power Convention, Torquay, on Friday, May 25th, was "Electricity in Rail Transportation," by S. B. Warder, Chief Electrical Engineer, British Transport Commission, British Railways Division. The main part of the paper (abstracts from which are reproduced here) dealt with the new industrial-frequency system which has been adopted by the British Transport Commission as the standard for future railway electrification in the United Kingdom, and gave reasons for this decision.

Future Demands for Electricity

DURING the next fifteen years the British Transport Commission have undertaken to carry out the following electrification schemes :—

Main trunk routes : Euston to Birmingham, Crewe, Liverpool and Manchester ; King's Cross to Doncaster, Leeds and York ; Liverpool Street to Ipswich, Clacton, Harwich and Felixstowe.

Suburban electrification : London, Tilbury and Southend ; Liverpool Street to Enfield and Chingford ; Liverpool Street to Hertford and Bishop's Stortford ; King's Cross and Moorgate to Hitchin and Letchworth ; Glasgow Suburban lines.

Extensions of Southern Region electrification : Completion of Eastern and Central sections of third rail territory east of Portsmouth, including Dover and Ramsgate.

There seems little doubt that this programme will be extended as time passes, until all lines which can be economically justified for electrification will be converted, for this is the lesson of electrification wherever started, that it must always go on extending.

The present proposed extensions amounting to about 1430 route-miles, will increase the British Railways electricity consumption by the approximate amounts shown in the accompanying table, adding a further 1488 million units to the present load, bringing the grand total up to 3697 million units a year. To this total the steady modernisation of all its installations will continue to add increasing demands for electricity at new depots, stations and marshalling yards as they come into use.

The British Transport Commission, already one of the largest single customers of the electricity supply industry, will thus for many years be contributing blocks of load which should be particularly attractive by virtue of the large proportion occurring outside the normal peak hours. The predominant traffic will be freight which is mostly moved at night and since the C.E.A. programme of expansion exceeds the railway requirements the improvement that will be caused to the national load factor is self-evident.

The new system of electrification which brings the industrial power system right on to the train also creates a new condition. With d.c. electrification separate sources of supply were necessary for ancillary services, although the former railway companies who owned their own power stations made full use of their ability to do as they liked with their own resources by operating depots with either low-frequency or d.c. power. This is not permissible under present legislation, for purchased current for traction can only be used for haulage or lighting of the vehicles. There are, however, many services requiring electricity which are concerned with the movement of vehicles, although not for direct application, all of which could be fed, for example, from pole type transformers from the overhead line system much more advantageously than by bringing in a separate outside supply from the local area board. Such circumstances are worthy of special consideration by the Central Electricity Authority as justifiable on the broader basis of the national interest, rather than on the narrower local interest.

The New System of Electrification

The B.T.C. had to choose between continuing with the well-established 1500V d.c. system already in operation on the Eastern Region out of Liverpool Street and on the Manchester/Sheffield/Wath lines, or to embark on all the problems that would have to be encountered in developing new designs and solving many new technical problems posed by the adoption of the 25kV a.c. system. It was clear that very careful consideration should be given to the possibility of obtaining for the railways those economies in the cost of fixed equipment which, by the use of high-voltage a.c. transmission at 50 c/s, were obtained by the electric power supply industry, now that it had been shown that locomotives and multiple-unit trains could be built economically to receive a.c. at the standard frequency.

Particular attention was to be paid to the practicability of obtaining the larger clearances necessary for the proper insulation of the higher voltage system. It seemed probable that because of the overbridges and tunnels the cost and difficulty of obtaining clearances might absorb a considerable part of the saving on the fixed equipment. As the investigation proceeded it became clear that these difficulties would be less than had been expected.

Power Supply.—It soon became apparent during the investigation that a radical difference would occur between the method by which power would be supplied to the railway depending on whether the overhead equipment had to operate at 1500V d.c. or with 25kV a.c. In the d.c. system substations are necessary at frequent intervals. For the London Midland scheme it would be necessary to build and equip approximately seventy substations in order to maintain

the average voltage at the locomotives at the same proportion of the nominal voltage at the supply point. Although it was not necessary to attempt to site each of these prospective d.c. substations jointly with the Electricity Boards who would be concerned, discussion with the C.E.A. showed that this would certainly involve the railways in supplying a 33kV cable system for about one-half of the route, so that substations spread down the line at intervals of approximately 7 miles could be fed from a restricted number of supply points where supplies of adequate power could be made available.

Estimated Power Requirements for Lines to be Electrified under the Modernisation Plan

Region	Scheme	Route-mileage to be electrified, miles	Estimated electrical power requirements	
			Maximum demand half-hour, kW	Units per annum, kWh (millions)
Eastern	Shenfield to Chelmsford and Southend (Victoria)	31	7,000	25
	London, Tilbury and Southend	77	37,000	130
	Liverpool Street to Enfield, Chingford, Hertford and Bishop's Stortford	45	15,000	55
	King's Cross and Moorgate to Hitchin and Letchworth, including the Hertford loop	63	25,000	100
	King's Cross to Doncaster, Leeds and York	186	60,000	350
	Liverpool Street to Ipswich, &c.	92	20,000	90
London Midland	Euston to Birmingham, Crewe, Liverpool and Manchester	495	90,700	556
Scottish	Glasgow Suburban	192	27,000	57
Southern	Stage I : Kent Coast lines	248	40,000	125

The adoption of a high voltage a.c. overhead contact system completely alters this picture. The use of a voltage such as 25kV (the value used by the S.N.C.F. and generally appropriate to our conditions, because among other reasons it will assist our manufacturers who will have to build to this voltage for export, and will provide for inter-running if later required) will reduce the number of substations on this scheme from about seventy to twelve. These twelve substations were estimated to produce a maximum sustained load of approximately 90MW with an annual consumption of approximately 550 million units, representing an average load equal to 70 per cent of the maximum sustained load.

Central Electricity Authority Equipment.—It was found that the most convenient way of supplying this load would be for the C.E.A. to install duplicate single-phase transformers stepping down from 132kV to 25kV at the twelve places concerned. In every case there is a C.E.A. substation close to the ideal position at which the railways would wish to take their supply.

The substation equipment to be owned and housed by the C.E.A. had only to be of the simplest type. On-load tap changing equipment would probably not be necessary on the transformers, each of which would be capable of maintaining the supply in emergency after simple switching operations. There would be only remotely controlled isolators on the high-tension side, and single-phase 25kV switches on the low-tension side. These would be owned by the Central Electricity Authority and would be similar to those which the railway would have to install throughout the system for feeding and isolating sections of the overhead line.

This country is fortunate in having a highly developed electric power grid corresponding to its highly developed industrial areas. This method of supply is technically simpler and better than the methods of supply which the French Railways have so far had to adopt. This is reflected in the fact that the Central Electricity Authority are prepared to tolerate the unbalanced load arising from a single-phase supply off their three-phase system because the supply is taken at that part of the system where its effect will be negligible. We shall in fact be about three times as well off as the French in this matter.

In addition to unbalance, due to single-phase loading, it was necessary to consider the effects on the C.E.A. and its customers of harmonic currents generated by rectifiers which will be used on the locomotives and trains. This problem exists with d.c. electrification where the rectifiers are in the substations, although the harmonics will be larger with a.c. electrification but, as in the case of unbalance, the same technical reasons which arise from the proposed method of supply will result in there being no greater and probably less, disturbance to others from this cause with the a.c. system.

The broad conclusion, therefore, in respect of power supply was that, on grounds of simplicity and economy in both capital outlay and maintenance costs, there is a marked advantage in favour of a.c. high voltage at 50 c/s. The advantage in respect of the L.M.R. investigation is reflected in the capital cost estimate on which we should pay the annual cost to reimburse the electricity authorities for their expenditure in equipping the supply points and maintaining them, namely : 25kV a.c., £1,500,000 ; 1500V d.c., £3,500,000. Of equal importance was that the 132kV grid system was likely to be more sure and reliable than a supply from an area board substation at a subsidiary voltage.

Railway Substations.—In favour of the a.c. system it should be further noted that, while it would be necessary to install approximately 300MW of converting plant in the substations for the d.c. scheme, it would only be necessary for the C.E.A. to install transformers having an aggregate capacity of slightly less than 200MW, because the wider spacing of substations will enable better use to be made of spare plant capacity and increase the load factor of plant in commission.

In addition, the cost of maintaining substation equipment will correspondingly be reduced, not only because of the smaller number of substations and of high-voltage switches, but because they will essentially comprise switching points instead of containing transformers and rectifiers necessary for the provision of 1500V d.c. The C.E.A. would deliver electricity to the railway at these feeder stations through two 25kV single-phase switches ; these would be similar to the switches used elsewhere on the system for controlling feeds to individual tracks and isolating one part of the tracks from another. Larger numbers of these switches will be required with wholesale electrification of British Railways.

It will be appreciated that the cost of buildings to house substation equipment will be considerably less for the a.c. system.

Track Sectioning Equipment.—It is necessary to install neutral sections between the sections of track fed by different feeder stations so as not to parallel the Grid through the overhead contact system. The technique for doing this is already established by an adequate system of signalling to instruct the driver to cut off power before reaching this section. He does not have to stop, as once he is past the neutral section as shown by another signal he can restore power. It can and may be arranged to be done automatically.

While such an arrangement as mentioned in the preceding paragraph is unnecessary with the 1500V d.c. system it is necessary (in order to keep the distance between substations as high as 7 miles) to install track sectioning switches, better described on the Southern Region as track paralleling switches, between substations to ensure a reasonable voltage on the contact line and to ensure clearance of faults with overload settings which will allow the free passage of normal and abnormal holiday traffic.

Because of the high voltage of the a.c. system, the conductivity of the overhead line is higher relatively than it is in the case of d.c. electrification. It is correspondingly easier to obtain clearance of faults so that the provision of track sectioning cabins for fault clearance is much reduced.

With both systems, additional sectioning switches are necessary for obtaining track isolations to allow for sections of track being taken out of service for maintenance, whilst allowing the flow of traffic to continue by the use of certain crossover roads, &c. On the d.c. system these facilities are frequently available because the number of substations and track sectioning cabins required to maintain the desired conductivity is sufficient to provide most of the sectioning required for operational reasons. On the a.c. system track sectioning switches are essentially required only between sections of track fed by different substations, so that additional switches are required for operational reasons.

Supervisory Control.—All switchgear in substations and track sectioning cabins will be remotely controlled. Control systems can now incorporate various improvements, including the adoption of a.c. voice frequency impulsing. It is intended to employ these wherever possible and it is probable also that a larger number of lineside telephones will be provided than in earlier schemes. With all this it is hoped that the required pilot cables will be less numerous and smaller in the case of the a.c. system because in the aggregate there will be fewer and simpler operations to carry out.

Overhead Line Equipment

With the 1500V d.c. system the train voltage can only be kept within the limits for which the traction equipment is designed by the provision of an overhead contact system, with a minimum cross-section of 0·6 square inch. Over some sections of the line it would be necessary to increase this at least to 0·75 square inch with provision for increasing this later to 1·0 square inch over some sections, if traffic develops and speeds increase as all phases of the modernisation plan become effective. All these cross-sections involve the use of a compound catenary system comprising a main and an auxiliary catenary and the contact wire. In contrast the 25kV, a.c. system requires only about one-third of this weight in copper, and thus lower stresses will be imposed on masts and foundations, with, of course, some additional expenditure on insulators.

While light mast and cantilever construction, which contrasts favourably with the relatively heavy structures required for the d.c. system, can be used with the a.c. system on two-track sections of line, many British main lines include four or more tracks over considerable distances, which makes the use of portal type structures spanning all tracks desirable. Nevertheless, the overhead lines would always be lighter, and often much lighter, in both weight and appearance, with a.c. than with d.c. This lightness will facilitate erection and, in particular, the use of mechanical appliances.

The current to be collected will only be one-fifteenth that at 1500V d.c. and the pantograph pressure only half as great. There should consequently be a significant increase in the life of the contact wire and of pantograph collectors.

Clearances.—With high-tension a.c. substantially increased clearances between the wire and earthed structures such as overhead steelwork, bridges and tunnel roofs, are required than is necessary for 1500V d.c.

British Railways have, however, had a considerable amount of experience with the clearances required in various conditions for 1500V d.c. Apart from experience with the 6·6kV a.c. system on the Lancaster-Morecambe-Heysham line, there is also the satisfactory experience of nineteen years of operation at substantially the same voltage of the L.B. and S.C. electrification. It is therefore safe to say that the 4in minimum clearance which is at present stipulated for 1500V d.c. and which was used for these a.c. electrifications is ample for both systems.

For 25kV a.c. it is proposed to use at first a basic minimum clearance of 11in. The significance of this figure will be apparent when it is realised that on the main line from Euston to Manchester and Liverpool, including all the diversionary routes, there are 904 overbridges ; of these, 478 (53 per cent) would require lifting to obtain the 4in clearance (1500V) and 701 (78 per cent) to obtain the 11in figure necessary for 25kV a.c. Out of this total full clearance cannot be obtained at ninety-seven bridges and special measures will be necessary. The total cost of lifting these bridges would be about £6,000,000 for 1500V d.c. and £9,000,000 for 25kV a.c.

It is, however, possible to overcome the difficulty of clearance in several ways. For instance,

lowering of tracks can in certain situations be effected, or solid insulation used in place of air on the underside of certain types of bridges. A more attractive solution is the use of a lower a.c. voltage on limited sections of track where a number of such bridges are close together and it is intended to use this method extensively in the inner zones of electrification near the big cities. It is proposed to reduce the voltage from the normal value of 25kV to about 6·6kV, at which voltage the same minimum clearance as for 1500V d.c. is required, viz. 4in. The transition from one voltage to another may be made automatically.

Surprisingly enough the investigations of the tunnel clearance problem has shown them to be less formidable than the bridges; there is adequate clearance in all double tunnels, only the single tunnels presenting difficulty, and in suitable cases reversion to the lower voltage may have to be made. The tunnel costs for the scheme investigated were £500,000 for the d.c. system and £1,500,000 for the a.c. system.

Thus the total costs for fixed equipment for both systems on the least favourable view with regard to the cost of obtaining clearance are :—

	A.C. £m.	D.C. £m.	A.C. as proportion of D.C. Per cent.
Capital cost of fixed equipment	29·3 ...	38·6 ...	76

It is fair to say that these figures cover conditions which are more difficult in the aggregate than those to be found anywhere else on British Railways.

Interference.—The cabling of open wire telecommunication circuits is essential with the a.c. system and desirable, if not indeed essential, with d.c., but it is in any case proposed in the modernisation plan to carry out an intensive programme of cabling open wire circuits to bring railway communications up to present-day standards. There is also no reason to suppose that the extensive adoption of a.c. electrification would cause undue interference with Post Office telecommunications broadcasting or television.

In both the 1500V d.c. and the 25kV a.c. overhead systems the running rail is used as the return conductor. As it is very imperfectly insulated by the sleepers and ballast a proportion of the current returns via the earth. This proportion will be higher in the case of a.c. than d.c. because of the impedance of the rails. No difficulties on this account are expected. Furthermore, the problem of electrolysis causing corrosion of buried pipes will not arise.

In regard to track circuiting there are possibilities that in the long run this should be cheaper for a.c. traction, since a variety of a.c. impulse systems are now becoming available. For the purposes of the comparison almost equal costs have been estimated.

Motive Power

All forms of electric traction enjoy certain advantages as compared with steam locomotives and, to a lesser extent, diesel traction. These advantages include (*a*) the ability to draw upon the output of a main generating station, (*b*) high overall thermal efficiency, (*c*) very high availability, (*d*) ease of handling, (*e*) cleanliness, and (*f*) reliability and ease of maintenance. Electric motive power units should therefore be designed so that full advantage can be taken of these special attributes, and an investigation of the whole British Railway policy in regard to train weights, length and disposition of marshalling yards, and the whole traffic pattern generally has determined the basic form these were to take.

1500V D.C. Locomotives.—D.C. electric locomotives operating on 1500V normally have pairs of 750V series-wound motors in series, which can be connected either in series or in parallel (or, in six motor equipments, also in series parallel). Speed control is by the insertion of resistances which are gradually cut out until either full series or full parallel speed is reached. The full series, or full parallel speeds, and the limited range of higher speeds obtained by field weakening of the motors, are the only speeds which can be maintained permanently without incurring losses in the resistances.

The maximum tractive effort is limited by the adhesion available between wheel and rail. Whilst adhesion is limited by other than electrical considerations, immediately the instantaneous critical value is reached by one wheel, the pair of wheels concerned begins to slip. In doing so, the voltage balance of the other motor of the pair is upset. As all pairs of motors are receiving the same voltage from the contact line, the voltage on all the motors of a locomotive is disturbed and in the absence of immediate action by the driver a state of instability very quickly arises. The whole question of what tractive effort can be maintained thus becomes indeterminate, since the driver's quickness of response is necessarily a variable. Any device which will reduce these peak values of current is helpful. Bogie design also affects the position and the latest Continental designs give good results in obtaining sharing of load between all axles of a locomotive. The trouble is most apparent in starting heavy loads, when the very fact that resistances are in series with the motors accentuates the instability mentioned above. It is least apparent in sustained high-speed working when tractive effort is low. Shortly, the fundamental weakness is that the resistance-controlled d.c. locomotive cannot, under adverse conditions, utilise all the adhesion that is available at any moment.

A.C. Locomotives.—It has been common knowledge that the series-wound a.c. motor with commutator and brushes has for many years been unsuitable for operation at 50 c/s. In recent years considerable progress has been made and the new a.c. motor which is being given extensive trials by the S.N.C.F. gives a greatly improved performance, although it still remains a complicated machine, demanding a high standard of maintenance.

Rectifier locomotives designed for operation with 25kV a.c. have series-wound d.c. motors permanently connected in parallel, fed by one or more transformers through a tap changing switch and rectifier. Speed control is by changing the voltage applied to all the motors by manipulation of the tap changing switch. Every speed can thus be maintained economically without incurring resistance losses as in the d.c. locomotive, and the limiting factor in maintaining any speed indefinitely becomes a function of motor design instead of control gear design.

As all motors are in parallel in the a.c. locomotive, they must (if of identical design) all exert equal tractive effort so that if one wheel begins to slip the other motors are not affected. If really bad conditions arise the driver can reduce the tapping, which immediately takes effect upon all motors. The impedance of the supply system and of the locomotive transformer also soften the peak current and reduce the tendency to slip during transition from one tap to another and lessen the risk of flashover. Good bogie design is equally important as for d.c. and is equally attainable. In contrast to the d.c. locomotive, the a.c./d.c. locomotive can use all the adhesion available at any moment between wheel and rail, and driving skill is of less importance.

Until recently locomotives for 25kV a.c. were expected to be more expensive than the 1500V d.c. equipments, and it was not claimed that they would have a better performance. A different position has now arisen since the S.N.C.F. claim that a year's experience of operation on the Valenciennes-Thionville line has shown that the 50 c/s, a.c./d.c. locomotive is not only more efficient than its d.c. counterpart, but is also cheaper in first cost and maintenance. For a locomotive of B_0-B_0 type, weighing 84 tons, the S.N.C.F. allocate loads of 1400 tons to the a.c./d.c. design and 970 tons to the d.c. design. By a slight change in gear ratio the a.c./d.c. figure has been raised to 1600 tons.

Although the benefits of better adhesion are more important when heavy trains must be handled on severe gradients, the improvement in adhesion will be particularly useful in permitting lighter locomotives to be built, with all that this implies in cost and by reducing the wear and tear on the track. In short, the a.c./d.c. rectifier locomotive has a marked superiority as regards starting and hauling loads requiring tractive efforts near the limit of adhesion, and shows to advantage at these speeds which do not constitute economic speeds for d.c. locomotives. It is further considered that there will be little difference in the cost of motive power units as between the two systems.

For express services B_0-B_0 locomotives would be satisfactory for either system, and these may be more expensive for a.c. than for d.c. For mixed traffic a B_0-B_0 a.c. locomotive would be suitable for hauling up to 1250 tons on gradients of 1 in 100. On past experience in this country it is unwise to expect satisfactory results from a B_0-B_0 d.c. locomotive with this load. It would therefore be necessary either to use a C_0-C_0 d.c. locomotive capable of hauling such loads or to double head those trains which fall between 1000 tons and 1250 tons with two B_0-B_0 locomotives, which would considerably increase the number and total cost of locomotives for the d.c. system.

A.C./D.C. Rectifier Multiple Unit Trains.—experience on the Lancaster line has confirmed the suitability of a.c. equipment using rectifier-fed d.c. motors for use on motor coaches. As a result designs have been prepared for mounting the electrical equipment on the underframes. The advantages of the a.c. system can therefore be confidently expected to apply also to multiple-unit stock, for when they are used in suburban service, with frequent stops, a considerable saving in energy consumption will result from the elimination of resistance losses, while the better adhesion characteristic will permit higher rates of acceleration or, alternatively, the use of a smaller number of larger motors with consequent saving in cost.

Costs.—The traction motors can be arranged to operate at full performance on both 6·6kV and 25kV. For the present the cost of a.c. electrical equipment must be assumed to be a little higher than the cost of the conventional 1500V, d.c. equipment, but when designs have been fully developed to take full advantage of the possibilities of the a.c. equipment, the ratio of costs may well be reversed.

Carriage Heating and Lighting.—The system of electrification has an important bearing on the system to be used for heating trains when steam is no longer available. Sooner or later electric heating must displace steam heating. There are no special advantages in d.c, heating which would justify its use with the a.c. system. If a.c. heating were used the ease with which a.c. can be transformed would allow it to be used for lighting and other ancillary services, and thus permit the elimination of axle driven generators. Consideration of the problem has shown an ultimate advantage on the London Midland scheme of the order of £1,000,000 in favour of the a.c. system, with enormous potential benefits when standardised for the whole country.

Conclusions

The case for preferring the 25kV, a.c. system is clearly established under each of the three main headings of power supply, overhead line equipment and motive power.

The financial comparisons which have been made in a specific case support the above conclusion from the economic point of view, both as regards first cost and running cost. The figures which have been published of this financial appraisal (a.c./d.c. = 92 per cent) includes elements of cost which are common to both systems and form part of the modernisation plan, and thus tend to mask the true cost comparison on a percentage basis. Likewise, no allowance has been made for the reduction in civil engineering cost which is likely to be derived from the adoption of a lower a.c voltage at certain difficult situations. These aspects, together with a reasonable probability of developments in the art of a.c. electric traction leading to lower costs suggest an eventual value of 86 per cent as the advantage which the a.c. system has in first cost over the d.c. system.

It will be recalled that the B.T.C. 1951 Electrification Report put the traffic density which would justify electrification at 3,000,000 to 4,000,000 trailing ton-miles per year per mile of single-track running lines, and estimated that this density existed or was exceeded on 5500 route-miles (14,700 s.t.m.) out of a total of 18,500 route-miles (34,000 s.t.m.).

It would therefore be reasonable to forecast an ultimate prospective economy of £100,000,000 if the economy to be derived from the adoption of the a.c. system in place of the d.c. system is achieved. This saving is based on the assumption that 75 per cent of the further economies potentially possible in the future, in the single-track mileage on which traffic density in 1949 exceeded 3,000,000, are realised.

Current Trends in the Specification of Structural Safety

By PROFESSOR SIR ALFRED G. PUGSLEY, O.B.E., D.Sc., F.R.S.*

The Cement and Concrete Association's recent symposium on the strength of concrete structures included, amongst other more specialised contributions, a paper of general interest by Professor Pugsley, which we reproduce here. Five main trends of thought on questions of safety in structural engineering are discussed.

THIS century has already seen considerable changes in the attitude of structural engineers towards questions of safety and is likely to see more. Such changes in outlook are commonly engendered by new experiences, particularly in the form of accidents and in the use of new methods or materials of construction. While, happily, we have not suffered unduly in this century from accidents, there has certainly been a high rate of change in materials and methods of construction, and this alone could account for our current preoccupation with questions of safety. Not least among such influential changes has been the development and widespread adoption of concrete construction in various forms, the theme of this symposium.

When engineers try to express and consciously to develop a change of outlook, they naturally use the scientific tools of their day, particularly the new tools. Thus at the beginning of the century the theory of elasticity tended to hold sway, next came statistical methods, and to-day the theory of plasticity. The fact that all these tools are essentially mathematical is itself significant and typical of our generation of engineers; we have almost all acquired, however unwillingly, a much more mathematical outlook than our opposite numbers at the end of the last century. We tend, therefore, to state and study our safety problems in much more mathematical terms than was customary in earlier times.

But this does not mean that we are "theorists" of an unpractical type for, to supplement and check our mathematics, we have experimental facilities undreamt of by our grandfathers. The amount of structural research work of an experimental type that is being conducted in this country to-day is much greater than was possible in the last century; and so also is the amount of *ad hoc* testing of structures for direct design purposes. As a result, the old idea of approval of structural strength by calculations alone is being modified by the acceptance of experimental results as evidence relevant to safety.

These two developments among engineers of this century—mathematics and experiment—are basic to the engineering "way of life" to-day, and form the natural background to the current trends discussed in this short paper.

At the beginning of this century, our profession, then at the end of a highly successful phase of Victorian engineering, gave little new thought to questions of safety. As a result of the history of construction in masonry and metals, culminating in the use of mild steel, structural safety questions arose, in most cases, only in the choice of suitable limiting working stresses or in provision for corrosion; for the former one normally gave no thought but to the adoption of stresses already standardised by custom or by law; for the latter only to the avoidance of thin steel members difficult to preserve by regular painting.

To-day the situation is very much more fluid. The coming of reinforced concrete alone has made us all think, for example, of what we really mean by the "strength" of a structure; when is a "crack" not a "crack," or when is it even a "good thing"? It has made us wonder, too, whether the Victorian policy with steel structures of aiming to keep the bulk of the material of the structure elastic under working loads was as universal and satisfactory a criterion for safe design as it was earlier accepted to be.

In any such criticism of the simple "working stress" method of controlling safety in design, we are most of us not, of course, wholly disinterested, nor should we be. The fact of the matter is that the Victorians were richer than us, and were not so vitally concerned with efficiency for the sake of economy as we have to be. Part of our enthusiasm for changes in the specification of safety thus results from the need for economy, but this very fact has, by linking our ideas of safety and efficiency, advanced our understanding of both in the structural field.

Out of this background has sprung the first important trend that I wish to note in this paper: the trend towards an increasing interest in the use of the ultimate strength of a structure (for a given loading distribution) as a means of specifying margins of safety. As I have remarked elsewhere,[1] this trend was partly due to the aeronautical developments of the First World War, but reinforced concrete has itself played its part. Once the idea arose that cracks on the tension sides of reinforced concrete beams could be treated as harmless, an increase of interest in ultimate loads was inevitable. The modern interest in plastic design methods for steel structures, typified by the work at Cambridge, is itself a child of the same outlook. However such methods develop, we are in for a period in which the safety of a structure is controlled, at least in part, by a study of its ultimate strength in relation to possible actual loads.

When in autobiographical mood, I sometimes like to recall how, when I first showed signs of interest in possible statistical relations between safety and structural strength, my efforts not only received little support but were very nearly officially suppressed. This was only a few years before the last war. We have travelled a long way since then. When the recent report on structural safety by a committee of the Institution of Structural Engineers was published, distinguished American comment was to the effect that its contents, whilst based on a statistical outlook, revealed too great a hesitancy to bring statistical mathematics right into the picture and so make probability theory the direct basis of numerical specifications of safety.

In its simplest form, the problem of safety can, of course, be stated in strict probability terms[2]: if the probabilities of given levels of loading on a structure are known, and the probabilities of its having given levels of corresponding strength are also known, then the likelihood of failure can be calculated. Thus, the strength to be provided for a given low risk of collapse can be determined. But, in so many practical examples, neither the one type of probability nor the other can as yet be accurately assessed.

Well before this sort of "ideal" framework was developed, reinforced concrete engineers were very conscious of the variability of the strength of concrete and sought both to measure and to minimise it. The statistical methods of "quality control" thus came to be used for concrete almost as early as for any other structural material. It was for building frameworks, in which concrete has so frequently been used, that statistical measurement of the actual loading on a structure—floor loading in this case[3]—was first undertaken; a move was thus made to combat the old tendency to adopt for design "worst possible loadings" largely unrelated to actual observations.

Our second trend, therefore, in the specification of safety is represented by the tendency to measure and control both external loads and internal strengths by statistical means, and to relate both by probability theory.

As soon as this last step is attempted, it is realised that the only direct way to express an accident risk for a structure—the probability of collapse, for example—is in terms of the likelihood of the event in the course of its own "life." That all structures have a measurable useful life is a commonplace among historians. Constructed originally to perform some useful function, structures in old age are either dismantled to make room for others or fall into decay to become objects of interest for archæologists. Yet until the last few decades, most structural engineers designed their structures with no clear recognition of such a finite useful life; given proper maintenance, they said, a structure could be made to last for ever without undue capital cost. It was not enough to point the lessons of history: that social changes and needs can vastly alter the conditions affecting the permanence of structures. Even the Pyramids enjoyed only a few thousand years of life in good condition, few churches have yet lasted 1000 years, and most dwelling houses disappear in a few hundred years. It is the modern need for economy, coupled with the high rate of change of industrial conditions typical of this century, that has brought fully into the open the idea that it is inefficient to design an industrial structure for anything but a short life, measured in tens rather than hundreds of years. And this viewpoint has, of course, been welcomed by the designers of such mobile structures as ships and aeroplanes, where the shortness of life was always apparent.

To these general conditions governing our modern outlook on the life of a structure must be added certain special technical factors of current importance. Since the last war, reinforced concrete engineers have had brought home to them, by some reports[4] on the condition of some early reinforced concrete buildings, both the newness of their art and the problem of keeping their structures sound for long periods. We have thus been reminded of the importance of watchfulness in design and maintenance against corrosion. Meanwhile, aeronautical engineers have been more forcibly reminded of the ravages of time that can come by fatigue, and now have to measure the safe flying time of their aeroplanes not in years, but in mere thousands of flying hours. Corrosion and fatigue are not new troubles, they are old ones with new importance, and railway bridge engineers, looking at both possibilities, see ahead the need for a lot of bridge replacements, thus setting a finite life to many familiar bridges.

Our third trend, then, is this realisation of the finite life of a structure and a movement towards its specification for design.

When one tries to decide upon the probable or the desirable life for some new structure, the purpose of the structure is a dominant consideration. The probable duration of that purpose with the owner, or a succession of owners, is as likely as not to determine the life actually required of the structure. It is in this required life that there must be very little chance of a structural failure or collapse. For quite apart from any loss of life involved, collapse would have measurable economic consequences. If these are very serious, it is clear the designer must aim to make the chance of collapse very small; if the economic consequences are slight, however, he need not expend so much effort to ensure avoidance of failure. The cost of designing and constructing a structure for safety can thus be weighed against the degree of safety attained. All this has now been stated in mathematical terms[5,6] and provides a clear-cut basis for the economic assessment of safety margins, omitting questions of human safety. The aim is simply one of economic efficiency; it is cheaper to build telegraph posts so that they will collapse in occasional very high winds and bear the cost of their replacement then than to build them so strongly that they will never collapse.

Our fourth trend is this move towards the linking of safety margins with economic efficiency.

The growing emphasis upon economic efficiency helps us not at all, at least directly, to understand, and if possible measure, the safety needed in a structure for human reasons—to prevent loss of life due to failure. The usual lay response to this problem is simple: any structure upon which human life depends must never fail. Yet not only is this perfect immunity impossible in nature; human beings do not really want it. The safety they want at a given moment depends remarkably upon the emotions of the moment,

* University of Bristol.

and whilst users of structures, as a group, are very conservative and demand a very high standard of safety, they can never afford to eliminate all risk. Thus, if the customs of structural engineers are examined in relation to human risks, one is studying both the accident psychology of the users of structures and the moral conscientiousness of structural designers. In these difficult circumstances it is no wonder that, in spite of the interest of the problem, so little progress has been made, though in some cases it may be possible to represent human risk in economic terms.[6]

Our fifth and last trend, then, is the growing interest in the problem of how allowance should be made in deciding upon safety margins for any human risks involved.

I have chosen to point to five important trends currently affecting the specification of structural safety. They are, in brief, as follows :—

(1) The importance of the ultimate strength of a structure.

(2) The value of statistics and probability theory.

(3) The development of the idea of a design life for a structure.

(4) The linking of safety with the economic effects of failure.

(5) The growing interest in the specification of safety from the human risk standpoint.

All five of these trends have their importance for reinforced concrete engineers, and all five are active among engineers of our generation working out a new view of structural safety—perhaps a first rational view—of which some of us may live to be proud. The report[7] recently issued by the Institution of Structural Engineers is a current contribution to this development.

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Sea Water Distillation Plant

By W. W. HUTCHESON, M.I.Chem.E., A.M.I.Mech.E.*

The second stage of a large water supply scheme for the State of Qatar in the Persian Gulf will be completed this year. For each stage of this scheme a sea water distillation plant, consisting of three sets of triple-effect evaporators with an output of 150 tons of distilled water a day per set, has been supplied by Bennett, Sons and Shears, Ltd.

DURING the past few years the Government of Qatar in the Persian Gulf has been developing the public services of the state to meet the needs of an ever-increasing population. The consulting engineers for water supply and sewerage are Messrs. J. D. and D. M. Watson, and the work is being done under the supervision of Mr. H. T. Hale, T.D., B.Sc., M.I.C.E., the state engineer. An important part of the development programme comprises a water supply scheme for the Doha area, which is being carried out in two stages. The first stage, which has been completed provides 120,000 gallons of water a day ; and this supply will be doubled when the second stage is completed in the autumn of this year. In each stage of the scheme half of the 120,000 gallons of water supplied is obtained from sea water distillation plant and the remainder from saline underground water obtained from boreholes situated about 12 miles from Doha.

All the] sea water distillation plant for this scheme is supplied by Bennett, Sons and Shears, Ltd., 9-13, George Street, London, W.1. The first distillation plant installed, which is to be duplicated in the second stage, consists of three sets of triple-effect evaporators, each set being designed for an output of 150 tons of distilled water a day from sea water. A diagram of one of these triple-effect evaporator sets can be seen opposite, and we also reproduce some photographs of the first plant in operation.

* Director, Bennett, Sons and Shears, Ltd.

It should be pointed out that the sea water in the Persian Gulf has a very high concentration of salts; for example, the chloride concentration is 24,400 p.p.m. Its scaling potentialities are also considerable as the calcium and magnesium contents are 530 p.p.m. and 1635 p.p.m., respectively.

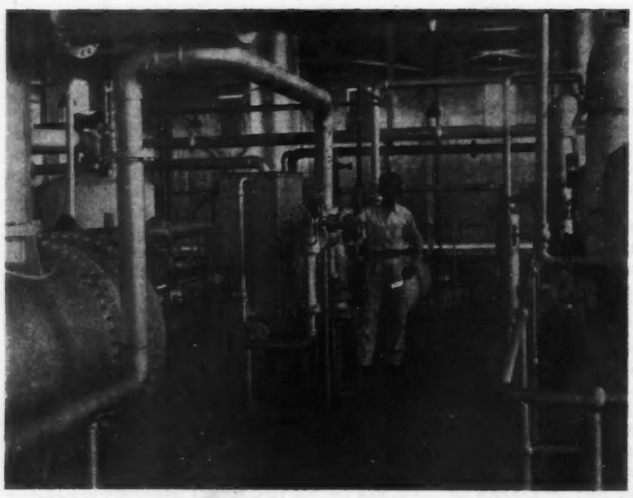
As oil fuel was readily available on the site it was decided that each of the series of triple-effect evaporators of the plant should be supplied with steam from an oil-fired Economic boiler, rather than design a plant with vapour recompression. Each boiler has a normal steaming capacity of 9000 lb per hour at 100 lb per square inch and from 212 deg. Fah. Although various designs of evaporators—such as the submerged calandria, the forced circulation or the flash type—could have been used, it was decided to adopt the more conventional coil design. The higher pressures which can be used with coil evaporators were advantageous in view of the water being handled ; their design facilitates cleaning by scale cracking ; and the coils can be removed for inspection and cleaning and refitted in twelve hours.

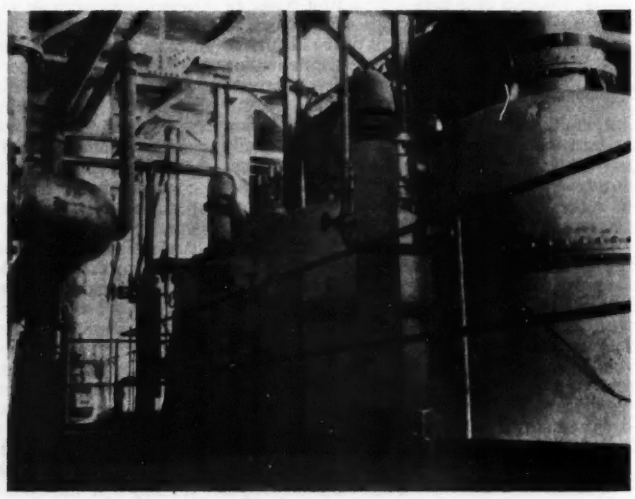
The pumping station for the main sea water supply is situated at shore level, where the water is screened before delivery to a main supply tank adjacent to the evaporating plant. The plant is designed for a maximum sea water temperature of 95 deg. Fah., the water being pumped in the first place through the main surface condenser, which deals with the vapours emanating from the third-effect evaporator. The feed water temperature varies according to the season of the year, but with the sea water fed in at 95 deg. Fah., the outlet temperature of the distilled water is approximately 116 deg. Fah., assuming a working vacuum of about 26½in in the third vessel.

A portion of the sea water leaving the main condenser is used as the feed to the first-effect evaporator, this water acting as the cooling medium for the distillate. This distillate, together with auxiliary exhaust steam, preheats the feed water to 168 deg. Fah. The water is then passed through a secondary preheater, using bled steam from the first-effect evaporator, where it is preheated to a temperature of 218 deg. Fah. The condensate from this secondary preheater forms a portion of the distilled water output of the plant. A third preheater is also provided to preheat the feed water to 227 deg. Fah. if desired, this being the designed operating temperature in the first-effect.

A forward flow is used in the evaporator system and the preheated feed water enters the first-effect evaporator, in which the working level is maintained at the level of the topmost coil. The maintenance of this level is made possible by the use of an anti-foam inhibitor in the chemical treatment of the feed water. Vapour from the first-effect evaporator is used as the heating medium in the second effect, a small portion of the vapour being bled off to the second stage preheater. Because of the lower pressure in the second effect evaporator, the sea water is sucked in, and the working level is automatically maintained at about the top coil. The vapour generated, plus the flash vapour, then passes to the coils of the third-effect evaporator, and the flow of sea water passes automatically from the second to the third-effect vessels. The vapour generated, plus the flash from the third-effect, is then condensed in a multi-pass condenser.

Condensed steam from the first-effect evaporator coils is removed by a steam trap and then discharged through a flash chamber ; after passing through the first stage preheater, this condensate is returned to the boiler feed tank,





(Left) First-effect end of sea water distillation plant with operator at the side of the ejectors. The main condenser can be seen on the left. (Right) One set of the triple-effect evaporators of a sea water distillation plant

where any make-up is supplied in the form of distilled water. The condensed steam or distillate from the second and third-effect evaporators passes through steam traps and flash chambers and is discharged to the outside of the tubes in the main condenser, where it joins the condensed vapour. A cooling section is provided in the condenser, and from it the combined distilled water from all sources is removed by a vacuum trap and discharged to the product tank.

The partially concentrated brine at a density of two-and-a-half to three thirty-seconds, is discharged from the third-effect evaporator and returned to the sea. On each triple-effect line the steam supply from the boiler at about 100 lb per square inch pressure is passed to the first-effect coils through an orifice plate. A second steam line supplies all the auxiliaries which consist mainly of steam-driven pumps. An auxiliary steam main supplies the two stage ejectors and a small supply is led to the third stage preheater.

As the boilers were initially charged with softened or distilled water, and as practically all the condensate is returned, the boilers are expected to remain in a clean condition indefinitely and without corrosion.

This triple-effect equipment has been designed for higher pressures than those normally used in such plants, but when the plant of the first stage was started up much lower pressures were actually used. The starting up pressures are shown in the following table with relative design pressures in brackets.

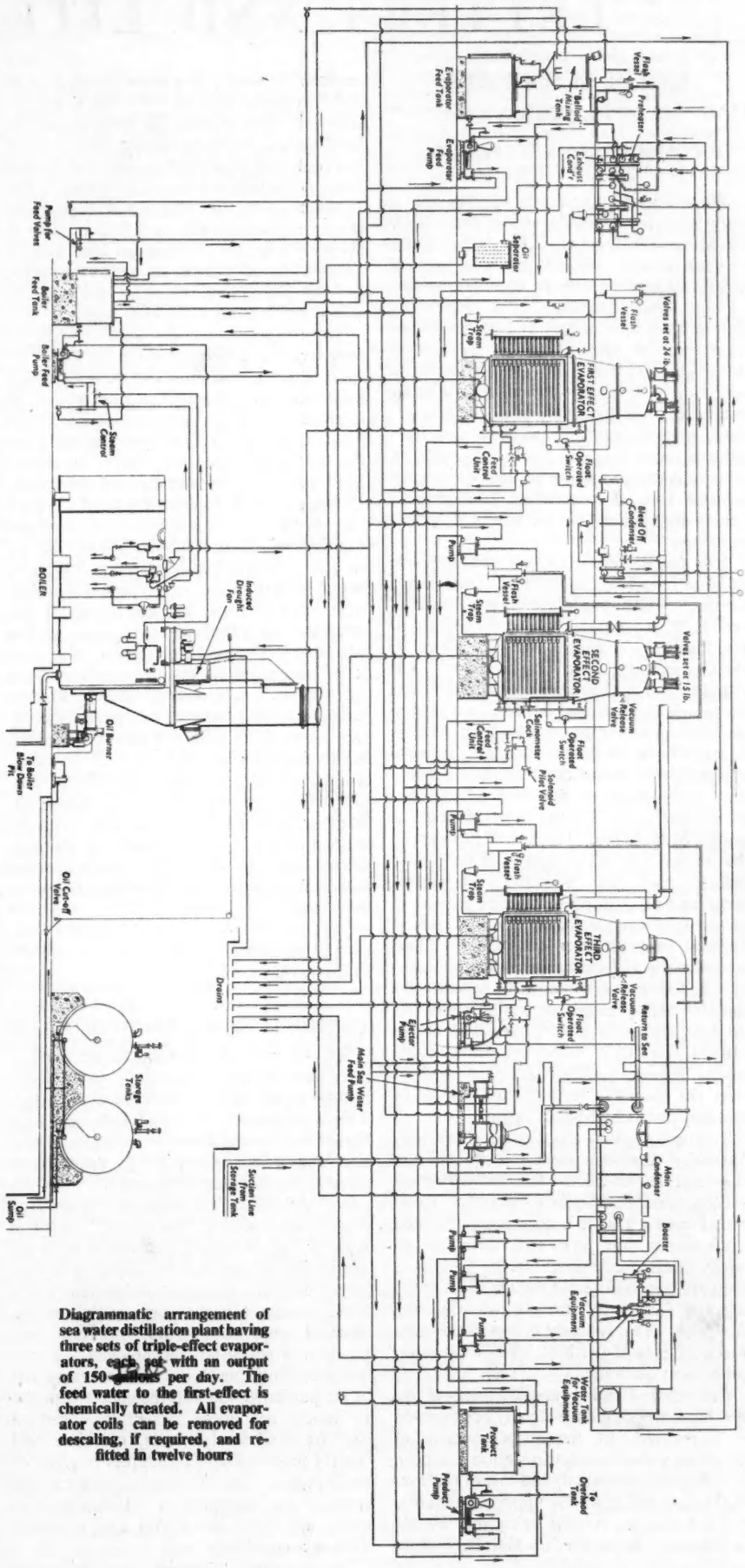
Steam pressure in first-effect coils	22 lb/sq in (80 lb/sq.. in)
Pressure in first-effect	10 lb/sq. in (23 lb/sq. in)
Vacuum in second-effect	20in (16in)
Vacuum in third-effect	27½in (26½in)

In the design figures the overall temperature drop was 204 deg. Fah., whereas on the initial trial runs the overall temperature drop was only 155 deg. Fah., which indicates the ample marginal allowance to counteract scaling. It has been found that the plant will run continuously for long periods at a 25 per cent overload.

From test results it has been shown that the produced ratio of distilled water to steam used is 2·4 to 1. The steam consumption figure embraces the steam supply to all sources, including the pumps and ejectors. The operating pressures on the first-effect are ideally suited to the addition of a steam-operated thermo-compressor, which would reduce the steam consumption to each triple-effect by 18 per cent, and increase the production ratio to 2·6 to 1.

As already mentioned, it was expected that scaling would be a problem in the evaporators and it was decided to use chemical treatment of the feed water entering the first-effect, and on the initial trials "Belloid" was used in conjunction with an anti-foam inhibitor. The chemicals are dissolved in a small mixing tank and introduced into the main feed tank in the form of a drip feed. During a period of over twelve months' operation, the problem of scale on the evaporator coils has been under constant observation. The combination of chemical treatment and scale "cracking" has now reduced the cleaning operation to the minimum, and it is now a routine practice to examine the first-effect coils every two months—the second-effect coils every three to four months, and the third-effect coils in six-monthly periods. The scale on the first-effect is soft in texture and easily removable, and the scale in the second and third effects is negligible.

The material of construction for the evaporator bodies is partly mild steel and partly close-grained cast iron. Their evaporation coils, constructed from solid drawn copper tubes, are designed to allow free expansion and contraction, to facilitate "cracking" of scale should this be necessary. A particular point in the design of the coils is a special gunmetal terminal which embraces the steam and drain ports in one single connection, as opposed to the orthodox coil which is fitted with twin terminals. This form of terminal will greatly facilitate the removal of the coils for cleaning or repairs. The main condenser tubes are of aluminium bronze and they are fitted into naval brass tube-plates and secured by ferrules at both ends. The fact that all the materials used in the construction of the equipment are resistant to corrosion was proved by a recent Lloyd's inspection at the completion of twelve months' operation.



Diagrammatic arrangement of sea water distillation plant having three sets of triple-effect evaporators, each set with an output of 150 gallons per day. The feed water to the first-effect is chemically treated. All evaporator coils can be removed for descaling, if required, and refitted in twelve hours

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

COMBINED HEAT-ELECTRIC GENERATION

SIR,—Your leading article of May 18th is very timely, particularly as the paper given by Messrs. B. Donkin, C.M. Johnston and C. Ockenden on January 31st last year was chiefly concerned with the economic aspects of the Pimlico scheme. The engineering details have been widely known for several years, but so often when the possibilities of schemes of this kind are discussed the objection is raised that no economic data are available. It is true without doubt that any such scheme must be worked out from scratch, according to local circumstances. The same remarks apply to plans on roughly parallel lines, for installing back-pressure generating plants in factories or public buildings.

It is indeed surprising that nothing came of the report on a "Heat Distributing Service" which was prepared by a firm of very high standing in 1942, at the request of the Planning Technical Sub-Committee of the Corporation of the City of Bristol. The rebuilding of such a large central devastated site would seem to lend itself to heat-electric generation, and these remarks apply with equal force to the City of London. Either a comparatively large central station could have been built, or the services provided by smaller units in large new buildings or groups of buildings. It is worth mentioning that such hotels as the Savoy and the Strand Palace have each operated independent generating plants for a number of years, and hundreds of other examples exist not only in England, but all over the world. Two exceptionally interesting cases are provided by London breweries, both of which have installed back-pressure generating plant. In the one case surplus electricity is sold to the Central Electricity Authority, while at the second brewery surplus steam is used to meet the domestic heating requirements of an adjacent block of flats.

It is known that the Central Electricity Authority has examined the possibilities of several thermo-electric schemes during the last few years, notably at Warrington. However, I believe that it is correct to state that arrangements are now well advanced to supply steam exhausted from generating plant at Spondon to meet requirements at the adjacent factory of the British Celanese Company. This is surely a step in the right direction, even if the heat load is industrial rather than domestic.

The technical and economic aspects of this method of working have already been proved in Germany. In the reconstruction of Hamburg a thermo-electric station has been provided, and in that city the cost of the connections, as well as all the apparatus required in the buildings, is now being met by the consumers. Elsewhere in Germany three back-pressure turbo-alternators, each of 50mW capacity, have been ordered for Charlottenburg, in connection with a similar scheme. It should be made clear that under the Electricity Act of 1947 the C.E.A. is definitely charged with the responsibility of investigating methods for the utilisation of heat obtained in connection with the generation of electricity from its stations. A few of the latter top the 30 per cent mark in the matter of thermal efficiency, but in view of the sorry plight of the National Coal Board's affairs every effort must be made to conserve fuel by attempting, wherever practical, to gain a much more worthwhile goal.

The foregoing remarks apply equally to industry, and a recent publication issued by N.I.F.E.S., entitled *Heat and Power Surveys*, indicates that there is plenty of room for improvement in all major industries. Such possible savings as 23·8 per cent are given for the brewing and soft drinks industries, 20·7 per cent for dyeing and bleaching, 15·9 per cent for paper and printing, and so on. By this it must not be inferred that vast capital expenditure is a necessary stipulation, as this is often far from being the case. Steam utilisation and steam generation must walk hand in hand, and the former, if not efficient, can completely neutralise all the advantages of a good boiler plant. Nor must it be assumed that the thousands of shell type boilers, so commonly used in English factories to-day, must all be condemned. If they are properly equipped with economisers, mechanical stokers, &c., as well as being maintained in first-class condition, very high efficiencies can be reached. Above all, however, they must be operated by properly trained stokers, and facilities for training, offered both by N.I.F.E.S. and numerous technical colleges, are available to-day in every part of the country.

JOHN FOX,
M.I.Mech.E., Assoc.I.E.E., F.Inst.F.
Hove, May 23rd.

TECHNICIANS AND TECHNOLOGISTS

SIR,—May I call attention to the increasingly familiar use of the word "technician" instead of the correct word "technologist." This is an example of muddled thought or a failure to understand technological relationships by journalists, film producers, civil servants and the public generally.

A "technician" is essentially a man or woman who uses a "technique," which is more or less stereotyped and results from the application of science to workshop or laboratory facilities. Thus a "technician" is a fitter, turner, wireman, erector, laboratory assistant, electrician, motor mechanic and the like, whereas a "technologist" is one understanding the basic sciences involved in his particular job and includes a capacity to initiate new ideas, design in a general way to suit developments, calculate and control processes and techniques in great or small degree. The professional engineer and chemist are examples of "technologists." These are clear distinctions and admit of little or no confusion.

The so-called "scientist" is a misnomer since obviously any serious attention to problems in a logical way must be a scientific process. The division of technology or "know-how" is broadly in the three divisions:

(1) Pure science (involving fundamental discovery or research).

(2) Applied science (technology or the interpretation of research and discovery).

(3) Production in a physical way at workshop level involving techniques which result from the technologist who controls and directs the work of technicians and their assistants who are usually semi-skilled or labourers.

I hope, Sir, you will take a lead in this and that your public will accept the foregoing definitions in future and so eliminate this shoddy practice, some of which I suggest is consciously aimed at the technologist proper in order to preserve and elevate the pure science practitioners and non-technical people, and tends to group as one the users of the spanner and slide-rule, whilst leaving the full credit of "know-how" to the pure science investigators. The D.S.I.R. is to be criticised also in such matters.

RONALD A. INGLIS

Bournemouth,
May 15th.

Literature

Noise. By A. VAN DER ZIEL. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 60s.

"WHAT sort of noise annoys a noisy oyster most?" "White noise has the highest entropy power." Thus may we illustrate the fact that "noise" is not something to be heard, and the word "noise" itself is just as metaphorical on many occasions as the adjective "white" which frequently accompanies it. The word has in fact become a piece of technical jargon, an abbreviation for spontaneous random fluctuations in a physical system, and is particularly applied to electrical systems. For a century communication engineers have been half-aware that noise is one of the limiting factors in telecommunication, but it has needed the impetus of two wars to make "noise" a key topic; the 1914–18 war nurtured the thermionic valve, the basis of highly sensitive amplifiers which readily manifest noise; and the 1939–45 war, in the development of radar, placed emphasis on the detection of feeble signals and in the last phases of mobile land warfare employed specialised radio communication equipment as exemplified by the British Army "No. 10 set."

The subject of noise is moreover a fascinating one, depending on two fundamental concepts of physics. The older of these is the principle of equipartition of energy, which stems from the work of Boltzmann and his contemporaries on the kinetic theory of gases, and which in the guise of Brownian motion was one of the earlier subjects to which Einstein made an important contribution. The relevance of Brownian motion to electric circuits was first predicted by Frau G. L. de Haas Lorentz in 1913, but not verified experimentally until Johnson's work in 1928. The second factor is the discrete nature of the electric current, an idea which can be said to date from the identification of the

electron in 1897. The "shot effect" in an electron stream was discovered by W. Schottky (who called it in German the "Schroteffekt"), and is said to take its name from an analogy between "the pattering of electrons on the anode of the valve" and a stream of small shot being poured into a container. (Unfortunately the electrons usually arrive at a rate of 10^{16} or so per second, so a slightly closer analogue is the tipping out of a lorry load of fine sand.) In the last quarter of a century much has been written on the detailed manifestations of noise in electron streams, but there remains the foundation that electric current consists of the movement of discrete electric charges, and fluctuations of current arise either from fluctuations in the number of charges moving or from fluctuations in their velocities.

This, then, is the broad field in which van der Ziel's book is placed. The philosopher may complain that the book in fact contains too little enlightenment on the matters of fundamental principle which have been sketched above; the extensive edifice of practical applications seems to be erected on hastily laid foundations. But the engineer may, on the contrary, welcome its direct approach to practical results. Equipartition in relation to electric circuits is represented by Nyquist's theorem, which in turn is extended to the fluctuations of electro-acoustical systems in Chapter 2 and of galvanometers in Chapter 16. Chapter 3, "Applications of Nyquist's theorem and of Schottky's theorem," is largely concerned with the concept of noise figure and methods of evaluating it; and Chapter 4 deals with reference sources of noise, amplifiers, and detectors, for measuring noise at various frequencies. The noise to be expected in valves and valve circuits is detailed in Chapters 5 to 10, except that travelling-wave tubes are treated in Chapter 15.

If the nineteenth century was the age of determinism, the twentieth is surely that of statistics, but of course our education has not yet caught up with this, and one cannot write a book on the entirely statistical subject of noise without including a section (Chapters 11 and 12) outlining the essential statistical tools: though whether it is necessary to describe even the elementary properties of the gaussian distribution is debatable. Certainly an account of the techniques for determining the power spectrum of a random function is a necessary part of the book, but the author's term Fourier coefficient is to be deprecated in this context because it normally means the coefficient of a term in the Fourier series representing the amplitude of a specific function, and not a measure of intensity or mean-square-amplitude. Chapter 14 on The Laws of Vacuum Tube Electronics, which provides the background for the technical calculations of noise in valves, is also a valuable part of the book. There are throughout the book places where the mathematics tends to look formidable, but this is inevitable if a statistical subject and one involving electron ballistics is to be treated with any rigour; there is no real mathematical difficulty, and practical conclusions are always given in detail.

By British standards the index suggests a lack of reference to the classical work on the subject, e.g. one fails to find in the index the names of Johnson, Moullin, F. C. Williams, but the last-named is in fact mentioned in the text. Even if the book is by some standards not a scholar's book, it will be welcomed by the engineer because it gives an admirably comprehensive review of the practical manifestations of "noise" in electric circuits and allied apparatus.

Die Design Handbook. Edited by FRANK W. WILSON. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 109s.

THIS valuable addition to the literature on press tool design is probably the most comprehensive and authoritative collection of material on the subject. The book is the product of a team of experts in the field of pressed metal production. It was planned by the American Society of Tool Engineers' National Book Committee comprising fourteen members, who, in the main, represent industry. The chapters in the book were compiled from a vast range of published source material and each one was then reviewed by one, and often two, acknowledged experts in the subject matter of the chapter. The result is a concise and factual survey based upon actual operating experience of press work.

The book begins with a chapter on pressworking terminology, which is of importance to the British reader who, for example, calls a die the female portion of a press tool; the American reader knows a die as a complete assembly of male and female portions. This section is followed by one devoted to stampings design. It deals with the design of the product in relation to life of the press tool, the correct choice of material for the product, and the achievement of precision and good surface finish.

A process planning section compares press operations with other manufacturing methods and lists the advantages of the process. The section deals with the redesign of products for production on presses and gives a step-by-step procedure when planning a new product for production on a press. The shear action in metal cutting is dealt with in another chapter which covers the problems of sheared edge deformation and provides numerous useful and comprehensive tables of piercing pressures required to produce holes of various diameters, stripping pressures and scrap allowances. This section is further supported by the following section on piercing and perforating dies, embodying the principles described in the chapter on shear action.

The processes of metal bending are dealt with and followed by examples of good press tool design for bending operations. The same pattern is followed for the basic processes of forming and drawing metals; each process section being supplemented by a following section showing the various tools and details of their design.

Various other forms of metal working press tools are described, and among the chapters worthy of notice are those dealing with large and irregular stampings, rubber pad and hydraulic press tools. Existing devices for the automation of press processes are reviewed under the section "Feeding and Unloading Equipment" which includes descriptions with illustrations of stock feeds, chutes, roll feeds, slide feeds, dial feeds, hoppers, &c. Mention is made of interstage gauging of parts automatically, but there is no detailed description of such devices, mainly because not many of them exist or have been described.

Under the heading of "Pressworking Lubricants," the descriptions of the various lubricants have been clarified by stating the origins of the materials incorporated in them, rather than by quoting the trade names used by various manufacturers. It is of value to note, for instance, that the vague term "lard oil" does not appear in this section.

There is an important chapter on safety in press work and the devices described have the virtues of being fool-proof and offering least obstruction to the free action of the operative. Several devices incorporating electric limit switches are described, but light-ray or photo-electric safety devices are not mentioned. Much useful information is offered under various headings with reference to carbide punches and dies, and non-ferrous press tool materials, such as wrought aluminium alloys. Working of the new metals such as zirconium and titanium is described.

Kreiszylinderschalen: Circular Cylindrical Shells. By D. RÜDIGER and J. URBAN. B. G. Teubner Verlagsgesellschaft, Goldschmidtstrasse 28, Leipzig, C.1. Price DM.24. (Bilingual: German and English.)

ALTHOUGH the first barrel-shaped shell roof was constructed by Dyckerhoff and Widmann in 1926, and such structures have been widely adopted since, it is a fact that although the possibilities of this kind of structure are known, knowledge of the theory is not as yet very widespread. The idea of assisting the designer by an extensive tabulation of internal forces and displacements is said to have been originated by F. Dischinger in 1935, but is here realised for the first time. After a theoretical introduction follow the tables themselves, which have been compiled for forty-eight values of the parameter $\varepsilon=\lambda^4\sqrt{4k/(1-\nu^2)}$, ranging from 0·03 to 0·30 for calculation of the first load term, and from 0·33 to 0·90 for calculation of the second load term. Among the extensive examples of applications with which the book concludes may be mentioned the case of a continuous shell with roof lights, single shells under various loading conditions, and continuous shells without edge beams. The theoretical basis is the work of W. Flügge, with the fundamental equations simplified by neglecting Bernouilli's hypothesis as proposed by L. H. Donnell in 1933. Numerical evaluation of the resulting differential equations is facilitated by the use of H. Neuber's dimensionless parameter ε, which connects the three independent dimensions of the shell: length, radius and thickness. By suitably defining the four redundants acting between each edge member along the generatrix and the circular cylindrical shell, it is possible to extend the tabulation of the integration constants for unit load cases, as proposed by Dischinger, so that stresses and displacements of the shell may be calculated for unit values of the redundants at each point of the shell.

Books Received

Miracle of World War II. By Francis Walton. The Macmillan Company, New York. 10, South Audley Street, London, W.1. Price 52s. 6d.

Electric Circuit Theory and Operational Calculus. Second edition. By John R. Carson. Chelsea Publishing Company, New York, N.Y. Price 1.88 dollars.

Principles and Practice of Radar. Fifth edition. By H. E. Penrose and R. S. H. Boulding. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 50s.

Reactor Handbook—Materials. U.S. Atomic Energy Commission. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 79s.

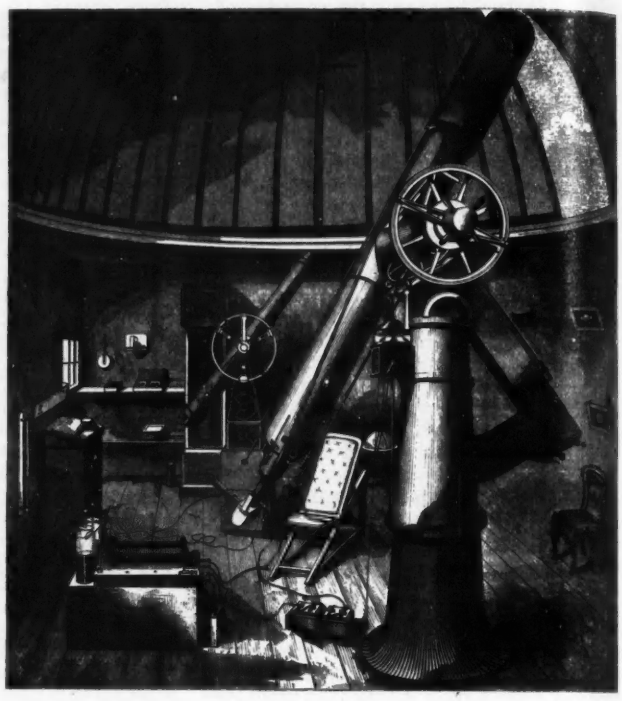
Spectrochemical Abstracts: Vol. IV, 1946–1951. By Ernest H. S. van Someren and F. Lachman. Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, London. N.W.1. Price 30s.

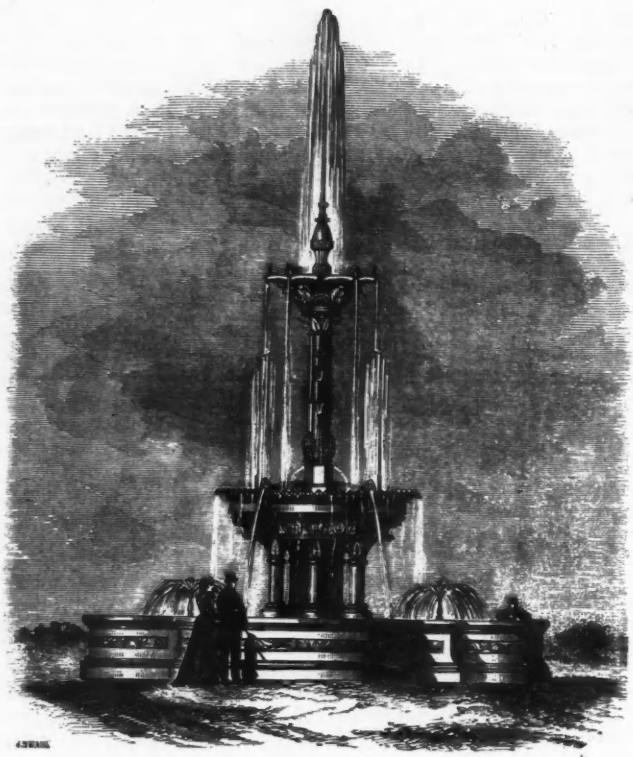
Peaceful Uses of Atomic Energy: Vol. II, Physics, Research Reactors. United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations. New York, U.S.A. Price 57s.

Peaceful Uses of Atomic Energy: Vol. 14, *General Aspects of the Use of Radioactive Isotopes: Dosimetry.* United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations. New York, U.S.A. Price 45s.

ENGRAVINGS OF 1869

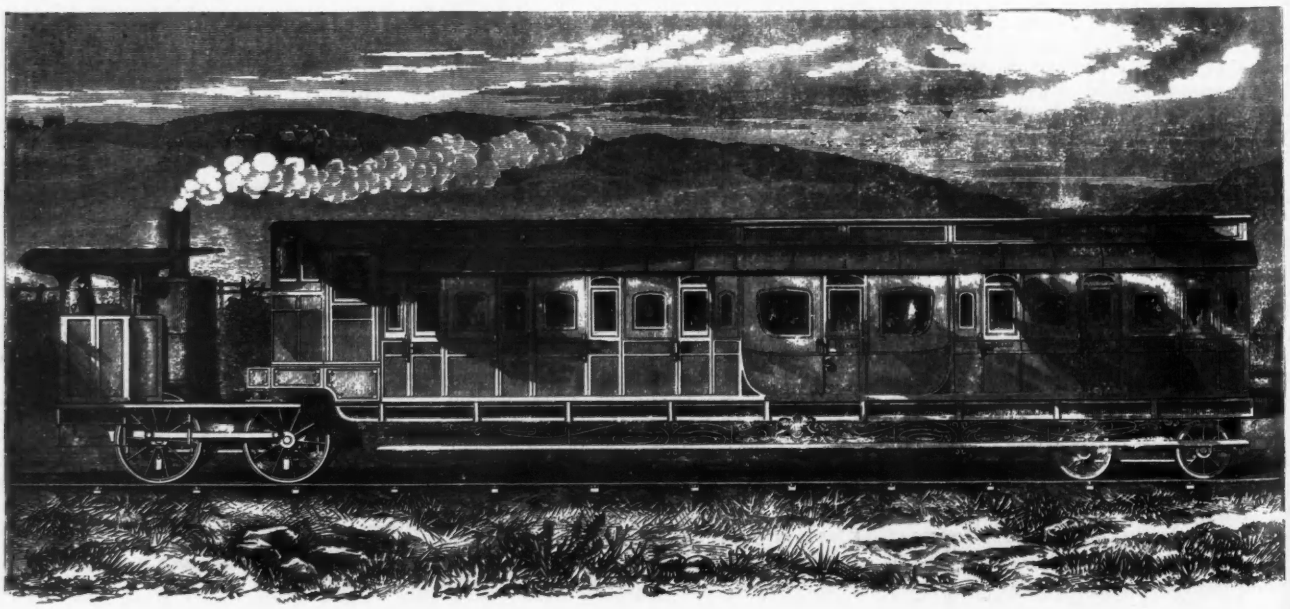
The observatory of Mr. William Huggins, F.R.S., at Tulse Hill, is shown in the right-hand engraving, reproduced from our issue of April 9, 1869. The "apparatus" illustrated is a "star-spectroscope" with the aid of which Mr. Huggins and a Professor Allen Miller examined the light of the stars "with highly successful results." The apparatus, according to our article on the subject, "consists of an object-glass to bring the rays from the star to a focal point; near the apex of the cone a cylindrical lens is placed to widen the point of light into a line, which line falls between the jaws of the slit of the spectroscope. The spectroscope consists of two refracting prisms of 60 deg., and a small telescope. The light from the ignited terrestrial substance to be compared with the light from the star is passed through the upper part of the slit, so is viewed through the same spectroscopic apparatus at the same time." The observatory itself, we noted, "consists of a building raised on iron columns, and having direct communication with one of the upper rooms of the house. The instruments stand on massive columns of cemented brickwork, which pass through the floor of the observatory, so as not to be affected by any vibration of the building."





In the engraving on the left there is illustrated a "handsome fountain manufactured in Ransome's patent concrete stone, from the designs of Mr. T. Blashill, architect, London." The fountain, which was described in our issue of February 26, 1869, was erected at Hong Kong. Its height was 20ft, "exclusive, of course, of the height to which the water may be projected by the jets, 370 in number, including an outer basin not shown." There were three basins belonging to the fountain proper, in addition to a lower enclosure 60ft in diameter. Our description adds: "the objects—animate and inanimate—selected for ornamentation are appropriate in their character and are delineated with remarkable sharpness, fidelity and beauty in the material employed."

The "combined engine and carriage for working branch railways," which is illustrated below, was designed by R. F. Fairlie and J. Samuels. The engraving is reproduced from our issue of February 26, 1869, in which we record that "the steam carriage may be described as consisting of two bogie four-wheeled trucks, with a platform between, on which the body or the shell of the carriage rests. The leading bogie is employed in carrying the boiler, engines, and supporting one end of the platform and carriage body; while the trailing bogie truck merely supports the other end of the platform and carriage body."



Iron and Steel Institute

During the recent annual general meeting of the Iron and Steel Institute, there were two sessions for the discussion of technical papers. They were held on Wednesday and Thursday, May 16th and 17th. Extracts from the discussions are given here.

ON Wednesday, May 16th, the two papers presented dealt with the acid Bessemer process. They were: "History and Practice of the Acid Bessemer Steelmaking Process in West Cumberland," by F. B. Cawley and D. R. Wattleworth, and "Control in the Acid Bessemer Process," by P. J. Leroy, J. G. Galey and F. B. Cawley. These papers were followed by the showing of a colour film entitled "Steel Road." It contained pictures of some of Sir Henry Bessemer's inventions, scenes from Workington, and views of the mines and works at Workington, where the acid Bessemer process is carried out.

Ingot Heat Conservation

The first two papers presented on Thursday, May 17th, were: "Cooling of 15-ton Ingots between Teeming and Stripping," by L. H. W. Savage and M. D. Ashton, and "The Cooling of Rimming-Steel Ingots between Teeming and Stripping," by M. D. Ashton, R. F. Perkins and L. H. W. Savage.

Mr. A. J. K. Honeyman (Steel Company of Wales, Ltd.): In our works practice with rimming steels, the minimum standing time is approximately forty-five minutes, and for this and other reasons the track time—time from teeming to strip—usually exceeds the minimum recommended by the authors. For that reason we have used their data more to avoid the hazards arising from too short a track time than to shorten the track time in accordance with the table. Probably the most serious problem affecting soaking pit practice is bunching. While ingots are normally supplied to the mill at a uniform constant rate throughout the twenty-four hours of every day, they arrive in the stripper bay in casts of 100 or 200 tons and several casts may arrive within a single hour. This bunching effect makes it difficult, if not impossible, to organise the soaking pit practice on the ideal basis recommended. In some plants bunching can to some extent be controlled by giving preference in the melting shops to certain qualities of steel, but where, as in our practice, the great bulk of the steels are of a similar quality—low carbon rimming steel—this remedy is not available. One other point is perhaps worth consideration, namely, that normally it is necessary for the ingot surface to be at or near rolling temperature for a certain minimum time to remove surface defects inseparable from normal steelmaking and pitside practice. A saving in soaking pit time might, therefore, lead to other and possibly more serious troubles.

Dr. R. G. Siddall (Sheffield University): I want to say a few words on the work which I carried out on data supplied to me. I worked on only one set of results, Trial No. 13, in which the initial mould temperature was 32 deg. Cent. I was supplied with all temperature data on the mould, not just on the mid-height plane; I dealt also with the other planes, including the top and bottom of the mould. I carried out a numerical integration to give the temperature on the ingot surface and within the ingot itself, for 45 points. I considered the ingot to be rectangular and considered just one-quarter of it, on the assumption that cooling was symmetrical. On the top I considered nine points, taking them at quarter distances. I did that for another plane a quarter of the way down, one at half-way down, one a quarter of the way from the bottom, and one at the bottom itself. I, therefore, obtained detailed information about temperatures at those forty-five points from teeming time to stripping time, and from those figures I have been able to obtain several comparisons with the authors' figures. This is an entirely different method of using the mould temperature measurements, but the comparisons between the two results are very good indeed. This is a slightly more refined method; it compares favourably with the authors' work and shows that their approximations and assumptions are entirely reasonable.

The first comparison is on the temperature of the ingot. The surface temperature of the ingot, calculated by the authors, starts about 1560 deg. Cent. and drops to about 1000 deg. Cent., being a smooth curve. That is for the mean outside temperature and the mid-height section. Calculating my points on the surface of the mid-height, I obtained a curve going down lower in the initial period and then rising above their curve. The maximum difference between the two curves at any time is about 100 deg. Cent., and the difference between them lies in the emissivity figure which we have assumed. The authors assume a constant emissivity figure of 0·5. Working on the temperatures which I was given, in the periods where my surface temperature is lower my emissivity is higher; and where my surface temperature is higher, my emissivity is lower.

The second comparison is on the heat content of the ingot at various times from teeming to stripping. They plotted a curve, and from it you get the heat content of the mid-height section. They obtained a smooth curve going down from about 300 deg. Cent. to something over 200 deg. Cent. I have nine points on the mid-section, of which I know the temperature, and the heat content corresponding can be worked out. I can work out the average for the mid-height. My curve fell slightly below theirs, the maximum difference being about 5 per cent of their figure. Once again the difference between the curves probably occurs in the fact that the authors worked out the figure, assuming that the heat in the mould which they measured is the total heat which has come out to the ingot, but that does not include vertical induction, which probably accounts for the higher figure. The last comparison is between the heat flux figure which they get and the one which I get; and that was within 3 per cent, using this method. I turn, lastly, to solidification time. They quote an equation, but it gives the rate of solidification at mid-height plane as equal to a constant times the square root of the time from teeming. In the case of the mould at 32 deg. Cent., that constant comes out to be 1·25. These figures are rate in inches compared with time in minutes. I worked out my mid-height figures and found the corresponding figure to be 1·19.

Mr. N. H. Turner (Appleby-Frodingham Steel Company): At Appleby-Frodingham, where the general quality of the steel produced has been no appreciable handicap to retaining as much heat as possible in the ingots before charging, the advantages of a short track time have been forcibly brought to the fore following investigations carried out as far back as 1933 on the cooling and heating of ingots. Compared with the methods used in the two investigations forming the subject of the papers we have just heard, these tests had none of the refinements which have been described and can be considered as only rough and ready. It is very well to consider that the minimum time necessary between teeming and stripping is just that required to have adequate solidification. The inside of the ingot mould, abstraction made of defective moulds, does not present a perfectly smooth flat surface and it is necessary to allow also for the shrinkage of the ingot to be such as to permit any asperities which may exist to be of no effect in so far as the withdrawal of the ingot from its mould is concerned. The time necessary for that occurrence appears to be greater than the time necessary for the required solidification.

As an example I will quote from an investigation we carried out in connection with the stripping of 10-ton ingots. Some of the ingots were solid enough to be stripped thirty-three minutes after teeming, but—and this point has some importance—it was necessary to wait until approximately sixty minutes for the percentage of stickers to have come low enough to give an indication that the gap was by then adequate. Approximately the figures were as follows: less than thirty-three minutes between teeming and stripping, 40 per cent stickers; less than forty minutes between teeming and stripping, 20 per cent stickers; fifty minutes between teeming and stripping, 9 per cent stickers; and sixty minutes between teeming and stripping, 2 per cent stickers. I call these figures approximate because they are essentially practical and, while care was taken to eliminate defective moulds from the assessment, no guarantee can be given that all moulds involved were entirely as new.

Another conclusion which we arrived at and which is touched on in the second paper is that it is useless to charge a large ingot into a hot soaker as quickly as it can be stripped. Time must be given for cooling to be achieved to the extent necessary to permit the soaking time being a minimum. This can be achieved by deliberately allowing the ingot to remain in the open air after stripping for a length of time related to the time which has elapsed since teemed. In that way such an amount of cooling of the outer surface is obtained that when the ingot is introduced in the hot soaker the heating of that part of it to rolling temperature is effected equally by heat obtained from the liquid centre and by heat obtained from the soaker proper. To suggest that a similar result can be achieved by having an initial soaking period in the soaking pit with the fuel input reduced is a fallacy. Either the pit will be allowed to cool below the temperature at which it has to be maintained to give to the ingot the necessary rolling temperature, and therefore heat will ultimately have to be provided to reheat the pit structure, or just enough heat will be supplied to prevent the pit from cooling below the temperature required for the desired rolling temperature. In this case some of that heat will be absorbed by the surface of the ingot, and this will cause a retardation in the rate of equalisation of the ingot temperature, with the corollary that the time the ingot will have to remain in the soaker will be above the possible minimum. Such methods would lead to inefficient fuel utilisation in more than one way.

Steel Solidification

The next paper, which was by B. Gray, was entitled "The Effects of Gravity in the Solidification of Steel."

Dr. A. H. Sully (British Steel Castings Research Association): Apart from the work which the Iron and Steel Institute has fostered over the years on the subject of heterogeneity in steel ingots, the British Steel Castings Research Association has for some years carried out investigations on the solidification of steel castings. In some of this work, notably that of Reynolds, the importance of convection was demonstrated and recognised. Mr. Gray has, however, realised the full significance of convective movements of liquid streams in modifying columnar crystal growth and in affecting the growth and collection of nuclear crystals. He has extended Northcott's arguments, and I find particularly convincing the concept which explains the limitation of growth of columnar crystals by localised convection of segregated liquid.

There is one snag about a lucid and authoritative paper, and that is that its very lucidity makes it very difficult to select points for argument. There is, however, a point that I should like to make in considering the growth and distribution of nuclear crystals. We must distinguish between three factors: (1) the downward movement of chilled liquid near the dendritic wall; (2) the release of latent heat as the nuclear crystal grows in size; (3) the formation of segregated liquid of lower liquidus as the nuclear crystal grows. Because of the last two of these three factors, I do not believe that the convection pattern in a solidifying steel casting is quite as simple as that in experiments carried out with dye tracers in which crystal formation is absent and so, consequently, are both latent heat and segregation effects.

If we take a case like that illustrated in Mr. Gray's Figs. 6(*a*) and 6(*b*), in which there is a downward convective stream of liquid containing

nuclear crystal nuclei near a dendritic wall, it is instructive to see what happens when a nuclear crystal grows in size in this stream. Two effects can be distinguished. First, the liquid immediately adjacent to the growing crystal gets hotter due to the release of latent heat. Secondly, the liquid immediately adjacent to the crystal is richer in carbon and segregating elements than the solidifying crystal. It therefore has a lower liquidus temperature. Here is a little paradox. Obviously the crystal cannot continue to grow if it is surrounded by an environment which is hotter and has a lower liquidus temperature. Also, the heat must get away. If one imagines the heat getting away, until the heat has got away, it must always be hotter than the dendritic wall and the equi-axial crystals which may be in that region. It seems to me that it means that the crystal cannot move downwards in the presence of that envelope of liquid. The liquid is hotter and less dense, so obviously the particle is always moving down against a very localised counter-current. I think that point must be clearly distinguished. The crystal and the liquid cannot stay in contact for any length of time. Obviously, therefore, although the stream as a whole is convecting downwards, within the stream there must be localised counter-convection around each growing nuclear crystal. It is possible in the end, if the process goes on long enough, to imagine nuclear crystals falling counter-current to a rising segregated stream of liquid in some parts of the ingot.

Mr. Gray has not overlooked this process, for he mentions, in considering micro-segregation, that " some of the film of segregated liquid that must surround each crystal as it grows in the current becomes detached and is left behind in the liquid." I would suggest that this must, in fact, always occur to some extent. This is, however, a minor point relating to the microscale of the process and certainly does not invalidate any of Mr. Gray's conclusions or detract in any way from the quality of his paper.

Ingot Structure

A paper on " The Effect of Temperature and Pouring Speed on Ingot Structure," prepared by the ingots committee of the British Iron and Steel Research Association, was then discussed. It was introduced by Mr. K. C. Barraclough.

Dr. R. G. Ward (Sheffield University) : There is no criticism that anybody could make of the paper. I only want to add a few observations on behalf of Sheffield University on certain aspects of the work. With regard to the intergranular fracture which the committee has found in sub-critically annealed ingot structures, Fig. 3 (in the paper) shows a fracture of this kind, with a predominantly intergranular fracture running from the outside to the centre of the ingot on which I have assumed to be the prior austenite grain boundaries, the grains of which are shown up by the ammonium persulphate etch. This type of fracture was brought to our notice about two years ago by Dr. Burton, and we have done a considerable amount of work investigating the problem.

As a matter of interest, the hot etches that we have been using—38 per cent hydrochloric acid, 12 per cent sulphuric and the rest water—show up the actual grain boundaries themselves in this type of steel on top of the primary dendritic structure, and the grain boundaries intersect the primary dendrites in the manner shown. We have cast a large number of varying ingot compositions from 15 lb high frequency melts into sand moulds. An interesting point is that the composition used by the ingots committee falls on the region of transgranular fracture in the small ingots, though their fracture was predominantly intergranular. Further up we have what was reported by Andrew in 1919, which was completely intergranular in the transgranular region in the small ingots. This is certainly an effect which is possibly due to cooling rate in the mould and will be influenced by pouring rate and pouring temperature. As we go into the higher alloy region, the susceptibility to intergranular failure or weakness becomes emphasised. The susceptibility is very difficult to destroy by heat-treatment. We think that this effect of alloying elements on the gamma grain boundary strength is an inherent form of weakness. It is not due to precipitation. We examined these boundaries under optical and electron microscopes, and no precipitations were to be found in the boundaries. The only evidence is hot macro-etching. The steels were not killed with aluminium. There is no aluminium nitride weakness coming in here. At the rate of 1 lb of aluminium per ton, I doubt whether this would have influenced the gamma grain boundary weakness. I feel that these are all the same phenomenon. It is our opinion that it is not proven that the weakness at the grain boundaries is a contributing factor in many forms of ingot weaknesses which are often predominantly intergranular and also contributes to hydrogen weakness and accounts for some of the effects noted with susceptibility to aluminium nitride weakness and so on.

Contributions to this discussion were also made by Mr. Basil Gray, Mr. J. E. Russell, Dr. L. Northcott, Mr. H. Allsop, and Dr. H. H. Burton.

Steel Characteristics at Low Temperatures

The session on Thursday afternoon, May 17th, began with a discussion on the four following papers :—" Stress-Strain Curves of Some Metals and Alloys at Low Temperatures and High Rates of Strain," by H. G. Baron ; " Yield Behaviour of Metals at Low Temperatures," by H. F. Hall and R. W. Nichols, and " The Hardness of some Carbon and Low-Alloy Steels at Low Temperatures," and " The Mechanical Properties of Carbon Steel Wire at Low Temperatures," by R. W. Nichols.

Dr. N. P. Allen, F.R.S. (National Physical Laboratory) : I do not wish to criticise or discuss the experimental methods which have been used, but to discuss in particular the paper by Hall and Nichols in relation to its general conclusions. The title of this paper has already been criticised. It seems to refer only to the yield-point, but actually there is a great deal more information in it than information about the yield-point, and I am particularly interested in the information about fracture which it contains.

From the lecture which Professor Mott gave yesterday it was clear that not everything about fracture is yet understood. He did his best to convince us that both brittle fractures and ductile fractures stem from the gathering together of dislocations at the grain boundary, causing a stress at an angle of 70 deg., which was in some way the origin of both ductile and cleavage fractures. In that case one would expect paralleling between the stress under which ductile fracture occurs and the stress under which brittle fracture occurs, and I have looked at these results from that point of view. I do not know whether I am biased, but I feel that these results indicate that the lack of parallelism between these two quantities is quite as obvious as the parallelism ; but the impressions gained by looking through a table of figures are not as useful as those obtained by the workers themselves as they examine one sample after another in their practical work, and I should like to ask them whether or not they think as a result of their work that the brittle fracture and the ductile fracture are governed by laws which are essentially different from each other or by laws which are essentially alike, because that is one of the ways in which the views expressed by Professor Mott yesterday can be criticised.

Another point of view from which I have looked at these results is that of the parallelism between the impact transition temperature as defined in one way and another and the tensile strength of the material in the brittle condition. At the National Physical Laboratory we obtained a very striking set of results on iron-oxygen alloys, showing that under certain conditions, when the tensile strength in the brittle condition in liquid air fell, the impact transition temperature rose correspondingly ; but immediately after that we obtained another set of results on iron-carbon alloys in which that parallelism did not exist. The authors will probably agree with me that the parallelism for which I was looking in this case is not shown in their results. We have to agree that the tensile strength at liquid air temperature is not a clear index to the impact transition temperature of the material. There are some interesting things which emerge from an examination of their results. If we take the same material both as annealed and as quenched and tempered, we find that when the tensile strength at liquid air temperature in the brittle condition goes down the impact transition temperature goes up ; but when we look at the materials in the as-rolled condition there is a curious anomaly, because the rolled materials appear to have a greater strength in the brittle condition at liquid air temperature than would be expected from the impact transition temperatures which are found.

I feel that the authors are right in laying great emphasis on the curve, which shows the variation of brittle strength with temperature. Some eight or ten years ago, when brittle fracture first came to be a bright star in the metallurgical firmament, it was very common for us to be told that it was all due to the crossing of the brittle stress curve with the yield stress curve, and that there was good theoretical reason to suppose that the first would be independent of temperature. I think that we must, in the light of the evidence, accept the fact that the brittle fracture stress is not independent of temperature. We have found that the variation of brittle fracture stress with temperature is not always the same. We have found cases—rather unusual cases, admittedly—in which the brittle fracture stress goes up with rise in temperature instead of down, as the authors of this paper indicate. For that reason I feel that perhaps the logarithmic relationship which they write down for the connection between fracture stress and temperature is a little premature. There is another interesting conclusion to be drawn. The authors think that whenever the proof stress of a material is raised the fracture stress tends to be lowered. The conclusion might be drawn that the tendency to brittle fracture increases every time the yield point is raised in a given material. If that is true it is a rather disheartening conclusion, but I wonder whether it is true and whether there may not be conditions such that it is possible to raise the proof stress and the resistance to brittle fracture.

In both the paper by Mr. Baron and in those by Mr. Nichols I notice that there is a great tendency to accept the Cottrell and Bilby explanation of the variation of yield point with temperature and to feel that their work in general is a confirmation of their theory ; but looking through the data without doing any mathematics on them, but taking the figures as one sees them, I do not feel that they entirely confirm that point of view. The curve which they give is of a very characteristic shape, and they have shown that for a certain number of materials that seems to be the case, but there are other materials which are outstandingly off the curve, and those materials are not of such a kind that one would expect the conditions which are assumed in the Cottrell-Bilby theory to be non-existent. Those materials are plain nickel steels and nickel-chromium steels. One would think that they would be like the others, and it is difficult to see why they should be off that curve. The same impression is given to me in looking at the effects of strain rate on the yield point, as shown in Mr. Baron's interesting paper.

Lieut.-Commander G. K. Rylands (Rylands Bros.) : There are one or two points which I should like to make on Mr. Nichols's paper on " The Mechanical Properties of Carbon Steel Wire." First of all, I see that rope wire is referred to, but it seems odd with a rope wire to have a reduction in area of 88–89 per cent. The author shows stress/strain curves, but I think that we need to know a good deal more about them—how they are produced, whether hot finished or cold, and how long after they were drawn the specimens were tested, as all those points will have a considerable bearing on the shape of the stress/strain curve. Perhaps, however, if it is merely a matter of a comparison between their behaviour at different temperatures that point may not be so important from the purely comparative point of view.

When we come to the notch impact test results we want to be certain that we are comparing like with like. What was the structure of those wires before drawing ? Was it purely sorbitic or ferrite-pearlite ? That might have a very serious effect on the results of the notch impact test. In the case of the Haigh-Robertson fatigue test the comparative value at different temperatures is important, but in my experience the value of the Haigh-Robertson fatigue test

end result is purely to compare the service condition of the material and it does not give much information about its ultimate performance in a rope wire. Some years ago a suspension bridge was built in America in which the wire in the suspension strands had admirable fatigue and elastic properties, but it crashed after a very short life. The wire from which those suspension strands had been made was replaced by drawn wire of far inferior fatigue properties to the original wire, but it is still in existence to-day. I do not think, on that basis, that too much reliance can be placed either on the Haigh-Robertson results or the type of bending test shown in this paper, although I agree that from the point of view of comparing what happens at different temperatures the results are of value.

Mr. G. M. Boyd (Lloyd's Register of Shipping): I have come here to try to learn something from all this work which would be directly applicable to the problems which we meet in engineering. There are a few questions which I should like to ask. The first concerns the attempts to find a correlation between transition temperatures in notch impact tests and the tensile test. It strikes me as peculiar that very little attention is paid to the character of the fracture in the tensile test itself. The shape of the stress/strain diagram is studied quite closely, but if the type of fracture obtained in a tensile test is examined it will be seen to vary all the way from a long neck with a V at the cone (*a*), through a rather more restricted cone with a shorter neck (*b*) to the other extreme, (*c*), where there is a more or less straight fracture across. Any of those three types may occur after the stress/strain diagram has gone through practically the same processes. There is also the question of where the extension or elongation is taken from, as indicated by the dotted line. It will probably give the same strain over the area involved in the fracture.

Impact Properties of Steel

At the final session of the meeting, there was a joint discussion on papers entitled "Effect of Phosphorus Content on Impact Value of Fully and Partially Hardened and Tempered Mn-Mo Steels," by N. P. Allen and C. C. Earley, and "A Study of the Impact Properties of Boron-Treated Steel," by S. J. Rosenberg and J. D. Grimsley.

Summing up the discussion on these papers, the president, Dr. H. H. Burton, said the subjects which had been considered were very live ones and were looming up in all kinds of engineering problems at the moment. The more light that could be thrown on them the better. There were similar problems arising at the moment in connection with very high-tensile steels for aircraft, and, in spite of what was almost overwhelming evidence, some people were far from converted to the idea that notch bar impact values had no relation to fatigue.

National Physical Laboratory

On Friday last, the Report for the year 1955 *of the National Physical Laboratory was published and an open day was held. We give below an account of some of the work described and displayed.*

DURING 1955 Sir Edward Bullard resigned from the post of Director of the National Physical Laboratory, and at present the Acting Director is Dr. R. L. Smith-Rose. During last year work started on the construction of a new Ship Hydrodynamics Laboratory at Feltham; this, besides open towing and steering tanks, will have a water tunnel whose circuit goes down about 200ft below ground level, with the test section in the top limb.

The aerodynamics division has engaged in numerous studies of boundary layer separation, particularly as precipitated by shock waves. A family of symmetrical aerofoils, for which the leading edge radius can be altered independently of other parameters, has been evolved and investigated, and it has been shown that, with a comparatively large radius, separation can be avoided up to a usefully high incidence. Other experiments employed an extended leading edge, drooped at 10 deg. or 20 deg., and suggested that the droop would defer separation up to higher Mach numbers. For this work at near-sonic speeds, the abrupt changes in pressure evoked are recorded by an interferometer, as illustrated in Fig. 1.

Since the wings desired for compressible flow are frequently prone to suffer separation at low speeds, a variety of techniques have been employed to study the resulting flow. A film has been made to record various methods of visualising the flow, such as the use of polystyrene particles or air bubbles in a water tunnel, or a grid of tufts downstream in a wind tunnel. Blowing at the leading edge and either blowing or sucking at the hinge of a control surface have been shown to suppress separation, and laminar flow along a body of revolution with a porous skin has been obtained. The work on blown flaps has been extended to the jet flap, and some experiments on a three-dimensional jet-flapped wing of aspect ratio three gave encouraging results. It is proposed to try blowing at the leading edge of a jet-flapped wing to avoid the separation bubble over the upper surface associated with extreme lift coefficients.

The severe stability problems of transonic flight are involved in several researches. A 9½in square induction tunnel, with slotted walls, has been equipped to measure the damping in pitch of a delta half-wing fitted with a flap. The wing is mounted on a torsional spring and maintained in oscillation by an electrical feedback loop; the power required is a measure of the aerodynamic damping, while the spring rate, and hence frequency, varies with the slope of the pitching moment curve. Similar equipment is being prepared for use in larger tunnels; here a body of high inertia is mounted on the inner end of the torsion bar, in order that the model can be excited by relatively small motor movements. A smaller torsion bar governs the high inertia body in order that the feedback loop shall not have to dissipate the energy generated by an unstable aerofoil. This type of model mounting allows extremely large pitching moments to be generated without the need for immensely stiff model supports. In the large-scale devices lift is measured by making the hub near the tunnel wall in the form of a thin-walled cylinder, able to shear under transverse load; the deflection is sensed by change in capacitance over one sector of normally concentric parts.

Other stability investigations were concerned with "buzz" of spring-located control surfaces in the presence of separation, and with the shedding of vortices from bodies of revolution at high Mach numbers and angles of attack.

The control mechanisms and electronics division is still assembling the Automatic Computing Engine, the design having been settled by experience gained with the ACE pilot model and its engineered version DEUCE.

The electricity division has developed the first atomic time standard, a caesium resonator. This establishes frequency with a precision of one in 10^9 within a few minutes, while ephemeris time requires lunar observations over several years to obtain the same accuracy. Michelson-Morley experiments using radio instead of light waves in a cavity resonator are considered to support the conclusion that æther drift is not observable.

The work of the light division has included a study of the ageing of standard filament lamps, which shows that a reversal of the current retards the loss of output. This effect is ascribed to the migration of tungsten along the filament.

The metrology division has determined the density of mercury to one part in 10^6 in order to

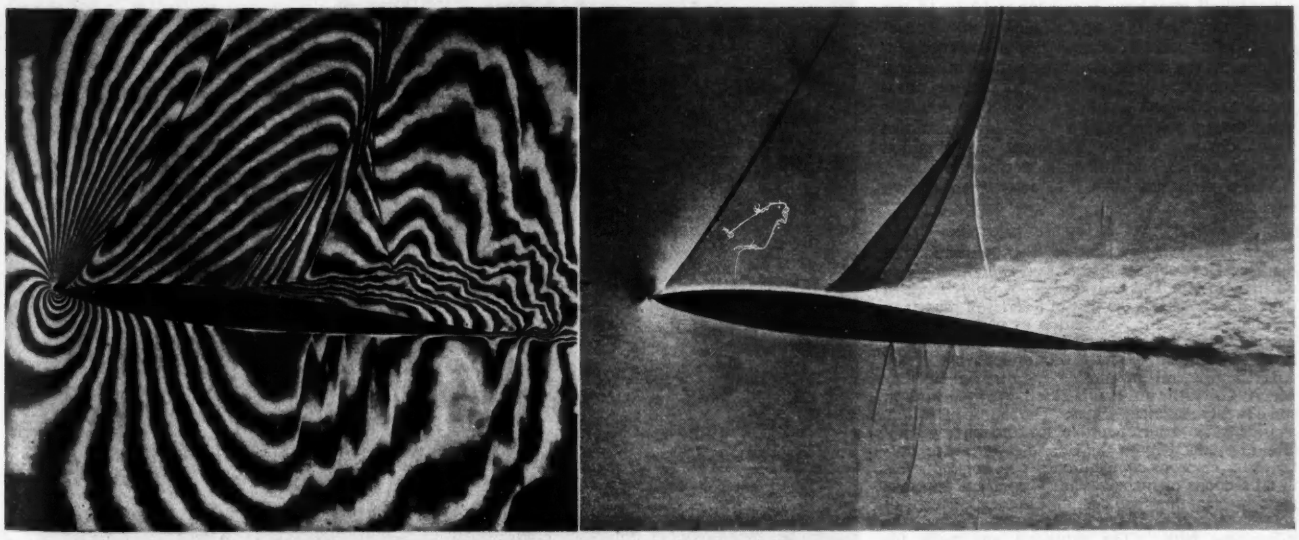


Fig. 1—The pressure distribution round a two-dimensional aerofoil can be obtained without tapping holes in the model by Mach-Zehnder interferometry; each shadow is a line of constant density. By comparison with the Schlieren photograph, it can be seen that the shock waves are evident as discontinuities. The roughly constant pressure on the aerofoil aft of the point of separation is apparent

establish the boiling point of water within 0·0001 deg. Cent. A 9cm cube of tungsten carbide, with faces true to 1×10^{-5}in, was weighed in air and in mercury whose isotropic constitution was checked in four laboratories. The mercury was poured round the cube in a vacuum, lest air bubbles should be trapped, and the surface tension around the tungsten wire supporting the cube was considered.

The engineering metrology section has developed a fiducial indicator to replace the vibrating reed in the proving rings used to calibrate testing machines. The micrometer, calibrated in tenths of thousandths, is adjusted to bring the needle seen in the window to a null attitude, as in Fig. 2, and it is found that settings are consistent to 0·00002in ; this gives the proving ring an accuracy of 0·1 per cent. The physics division was responsible for the aircraft crash accelerometer described in these columns on August 26, 1955, page 305, and the research on hearing mentioned on page 799, December 2, 1955. On the open day it displayed a technique for measuring the elasticity of ceramics or metals in ambient temperatures up to 1000 deg. Cent., a short specimen being loaded in compression by tensile filaments harnessed to an ultrasonic resonator.

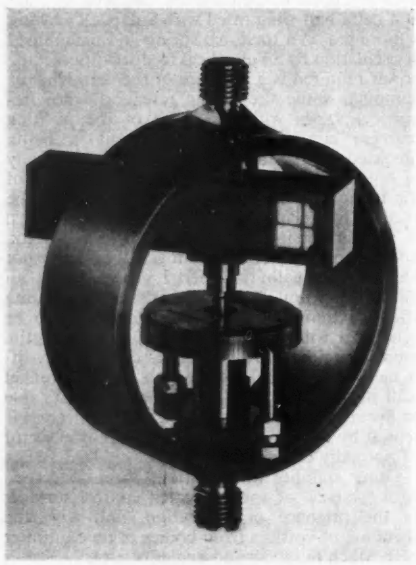


Fig. 2—A mechanical fiducial indicator is incorporated in this proving ring to allow the micrometer to be adjusted within 0·00001in

The ship division reports evidence that a riveted hull may have a resistance 12 to 15 per cent greater than that of a welded ship. Radio-controlled models demonstrated, in one case of a twin-screw tug design, an improvement in control and manœuvrability with inward turning compared to outward turning propellers. Another interesting research was on the performance of a 5½m yacht where close agreement was obtained between model and full-scale performance.

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HOT DIP GALVANISING.—A new publication of the Zinc Development Association is entitled "Productivity in Hot Dip Galvanising—A Study made in the U.S.A." This is the first of a series of reports to be published by the Association as part of its productivity service for the general galvanising industry. It is based upon a study on productivity in the American general galvanising industry in 1954 by Mr. A. G. Northcott, and is based upon the work in some twenty American plants. The four main factors considered to be responsible for the high general level of productivity in the U.S.A. galvanising industry are : vigorous competition ; cost consciousness in all sections of management ; constant improvement in operating methods, and the achievement of greater continuity in the flow of work through the galvanising bath. Ten proposals are made for increasing productivity in the U.K. galvanising industry. The report is issued by the Hot Dip Galvanisers Association, 34, Berkeley Square, London, W.1, price 7s. 6d.

Diesel Tugs for Southampton

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

ALTHOUGH the Southampton, Isle of Wight and South of England Royal Mail Steam Packet Company is more generally known as a concern operating the mail service between Southampton and Cowes, as well as maintaining pleasure sailings along the South Coast, the more important of its activities is in fact to be found in the fleet of tugs based on Southampton. Nine steam tugs constitute the present fleet and all of them are twin screw, an unusual state of affairs. The two new vessels now joining the fleet, "Atherfield" and "Culver," are the first tugs to be built for this company which are driven by diesel engines, and a number of new features are being incorporated. "Atherfield," illustrated herewith, is already in commission, while her sister ship is to be launched on June 8th.

The firm of John I. Thornycroft and Co., Ltd., built the vessels at the Woolston yard, Southampton. The tugs are designed primarily for handling tankers at the jetties of the Esso Petroleum Company's oil refinery at Fawley, where they will be permanently stationed. On account of their specialised work extensive fire-fighting apparatus has been provided. Among other special features may be mentioned bridge control of the engines, and a quick release gear, for disengaging the towing hook, which can be operated from the wheelhouse or from a position on the boat deck. For the first time solid rubber fenders, both side and bow, take the place of the coir rope fenders formerly fitted in the bows, and the rubbing side fenders of wood. The two anchors are recessed into the plating at the bows. For the first time the lifeboats have been made of aluminium alloy; they are 16ft long

Twin-screw diesel tug "Atherfield," intended primarily for handling tankers at Fawley

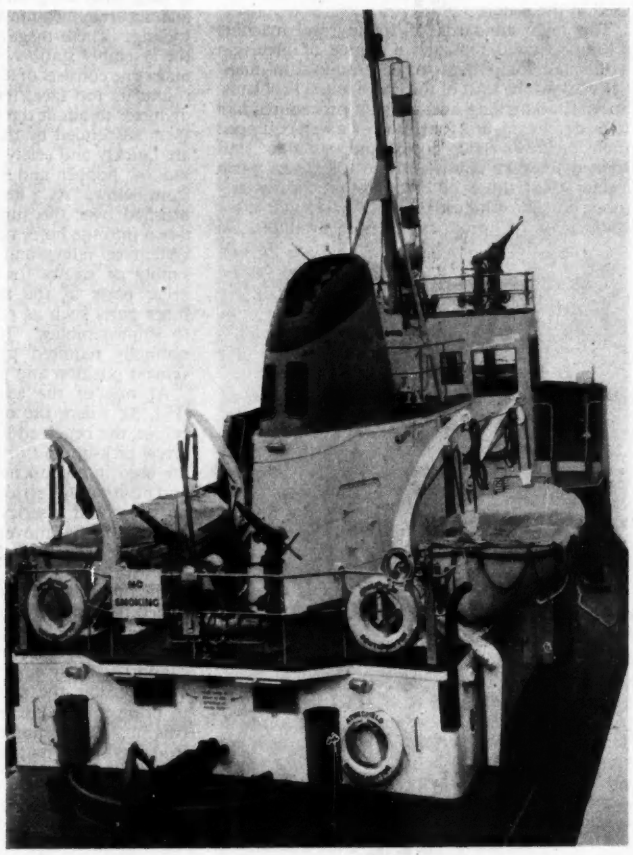
The tug is propelled by two diesel engines developing collectively 1340 b.h.p. at 500 r.p.m.

and carried in Columbus Col-Crescent davits, each boat carrying eight persons.

The principal dimensions are as follows :— Length overall, including fenders, 112ft 1½in ; between perpendiculars, 100ft ; breadth, moulded, 27ft ; draught, amidships, 9ft 9in ; extreme draught, 11ft 11in ; tonnage, 253 gross. The tugs are built to Lloyd's classification 100 A.1 " for towing services " under their survey. The deck machinery consists of a windlass forward which is electrically driven, and a 24in diameter warping capstan aft, the capstan motor being positioned below the main deck, both units being by A. Barton (Engineers), Ltd. The steering gear is of the hand and power electric-hydraulic type supplied by Donkin and Co., Ltd., the motor rams and pump being in the steering compartment coupled to twin spade type rudders. The bridge control is by duplex-ram telemotor gear. The tow hook is a " Love-ridge " pattern spring type with a spring-loaded quick release for disengaging the tow rope. The quick release can be operated from the wheel-house or the boat deck.

The main propelling machinery consists of two Crossley Brothers type " HGN6/50 " six-cylinder, unidirectional, marine diesel engines, two-stroke cycle, the cylinders having a bore of 10½in and stroke 13½in. The engines are each coupled to a Hindmarch/MWD oil-operated, reverse-reduction gear, designed and manufactured by Modern Wheel Drive, Ltd., each engine driving outward turning propellers through a 2½ : 1 reduction gear. The engines develop collectively 1340 b.h.p. at 500 r.p.m., with a propeller shaft speed of 198 r.p.m., which gave a mean speed of 11·78 knots on trials. The engines can be operated at the control position in the engine-room or operated by remote control on the bridge. Each engine is a self-contained unit, with its own associated auxiliaries built into the engine, and driven off the main crankshaft. These auxiliaries include an air compressor, a cooling water pump, a bilge pump, lubricating oil pumps and fuel pumps. As well as the aforementioned there are independently electrically driven pumps consisting of a standby cooling water pump, a standby lubricating oil pump for the oil-operated gearbox, a bilge and general service pump, and a lubricating oil purifier ; there is a diesel-driven air compressor, which is used when starting up from cold. To provide the necessary electricity there are two 85 b.h.p., 1100 r.p.m., 50kW, 220V d.c. Campbell and Isherwood generator sets, each direct driven by a Crossley five-cylinder diesel engine, and one 25kW, 220V d.c. generator set by the same makers driven by a Crossley three-cylinder diesel engine. The main engines have emergency remote control starting gear for bridge operation, but at present this is not connected up. The propeller shafts run in gunmetal bushes, white-metal lined, in stern tubes, with oil lubrication and United States Metallic Packing Company's oil-tight glands between the propellers and aft stern tube bushes. The propellers themselves are of manganese bronze and four bladed.

The fire-fighting equipment is very comprehensive : each vessel has six 4in swivelling monitors, four being positioned above the top of the wheelhouse and two at the after end of the boat deck. In addition to the monitors, four double-hose valves with swivel bends are fitted on the main deck. Each of these fire points is capable of discharging either water or foam. The main fire pump is a 10in, two-stage Pulsometer centrifugal, driven by a Crossley six-cylinder, two-stroke diesel engine running at 1000 r.p.m. against a total head of 276ft. The vessels each carry 6000 gallons of foam compound in two tanks built into the hull. This is discharged into the water stream of the monitors and deck hoses by an electrically driven centrifugal pump, capable of delivering 80 gallons per minute at a pressure of 140 lb per square inch, which will supply all units with foam for about ninety-five minutes. The maximum range of water throw is from about 170ft with a 1⅜in nozzle to 220ft using a 2¼in nozzle. Foam can be thrown about 80ft from monitors or hose branch pipes. The fire-fighting equipment has been supplied by Merryweather and Sons, Ltd., and Foamite, Ltd.



Since the tug is designed primarily for handling tankers it has been thought wise to provide extensive fire-fighting equipment

On the bridge deck aft of the wheelhouse is the captain's cabin, which is comfortably furnished, and on the main deck, aft of the forward windlass, on the port side is the mate's cabin and on the starboard that of the chief engineer, astern of which there is the officers' mess ; here a false level floor is fitted to overcome the otherwise excessive sheer. Further astern to port is the crew's toilet and to starboard that of the officers, in both of which shower baths are provided. Finally comes the towing gear. On the lower deck there is a chain locker in the bows, behind which lie the crew's quarters and mess room, astern of this the engine-room, then comes a hawser and hose store, and next the steering compartment. Below all are tanks for fresh water, foamite, and oil fuel. Both the mess rooms are fitted with a sink unit, electric stove, refrigerator, cupboard stowage and an extractor fan, natural supply and exhaust ventilators being fitted in each compartment. For a vessel of this class, the accommodation provided for officers and crew is of a high standard.

During the trials the static maximum bollard pull proved to be 17·75 tons. During a short demonstration cruise the efficiency of the fire-fighting equipment was specially noticed, as also was the manœuvrability and general handiness of the vessel. It will be interesting to compare the performance of these two diesel tugs with that of the latest steam tugs " Hamtun " and " Sir Bevois," of comparable size, built in 1953 and fully described in our issue of December 18, 1953.

Modernisation of London Transport District Line

WITH the placing of a contract for the construction of a new depot at Upminster, London Transport has embarked on the first stage of a £2,350,000 scheme for modernising the eastern section of the District Line. The implementation of this scheme as a whole will be phased with the Eastern Region of British Railways' London, Tilbury and Southend electrification scheme. The works to be carried out by London Transport fall into two main categories concerned with the depot and local tracks.

At present the District Line service east of Campbell Road Junction (near Bow Road Station) is operated over 12½ route-miles of electrified tracks managed and maintained by the Eastern Region of British Railways, which also make use of them for some steam freight workings and occasional steam-hauled passenger trains. It has long been recognised that complete segregation of control of the respective services provided by the two undertakings, and of the power supply, signalling and tracks relating to each, is desirable. The first step towards segregation was taken last July, when responsibility for the power supply to the Bow/Upminster services was transferred from the Eastern Region to London Transport.

An essential part of the Eastern Region's London, Tilbury and Southend electrification scheme is the remodelling to be carried out by the Region in the Barking area. This, among other major works, includes a new single-track flyover and a new single-track flyunder to carry the westbound District Line over and under the Fenchurch Street/Southend Line, as well as a main line flyover and extensive permanent way and platform alterations. These works can be regarded as the key to the whole of the electrification scheme, and, together with removal of the junction at Bromley, they will segregate the local and through tracks as far as Upney. London Transport will carry out minor permanent way alterations and re-equipment to modern standards, together with installation of two-aspect colour-light signalling as standardised on the Underground system, to be ready when local tracks between Campbell Road Junction and Upney come under London Transport control following the Barking rearrangement. The remaining section of local tracks (i.e. from Upney to Upminster) will be similarly re-signalled and re-equipped as necessary before transfer to London Transport control.

Ancillary works to be undertaken by London Transport in connection with this part of the work include a new substation at Plaistow ; additional plant in existing substations, and their re-equipment, where necessary, to modern standards ; the provision of signal cabins and staff accommodation ; and an additional platform at Upminster for Eastern Region Romford Branch trains to compensate for the proposed use of the existing Romford Branch platform exclusively for District Line trains.

As the Eastern Region's electrification programme involves the construction of a new rolling stock depot for the London, Tilbury and Southend electric stock on a site including the East Ham depot at present used by District Line trains, a new District Line depot will be necessary, and a site for it has been chosen about half a mile east of Upminster Station. The new depot is designed to accommodate thirty-four eight-car trains (with possibility of future extension) and stabling sidings for thirteen trains are also to be provided at Upney.

British Wrist Watch Factory

A considerable amount of progress has been made in the engineering and allied industries in efforts to relieve the shortage of skilled personnel, by the breaking down of individual operations and introduction of special tooling to enable the production of precision equipment by readily trained semi-skilled labour. We recently saw a particularly good example of work of this kind in the British watchmaking industry in a factory of Smiths Clocks and Watches, Ltd.

THE manufacture of high-quality watches in any appreciable numbers virtually ceased in this country in the early 1930s, although the industry was partially revived for pocket watches during the war years owing to difficulties in obtaining supplies from overseas. In 1946 Smiths Clocks and Watches, Ltd., decided to restart the industry, with Government support, and as part of this scheme to set up a works at Cheltenham for the production of high-quality wrist watches of British manufacture. At that time there were but few people in this country who knew much about fundamentals of performance of watches of the standard it was proposed to make, and still fewer conversant with their manufacture. There was also practically no labour available for the class of highly skilled operations associated with watch assembly and adjustment. Now, within the relatively short space of ten years, a complete plant has been laid down, methods based upon the best-accepted practice developed and suitable personnel trained for the production of components and the assembly of wrist watches.

Wrist watches are now being made at the Cheltenham factory, in a range of sizes from 5¼ ligne to 12 ligne, that are claimed to be equal in quality and performance to the best watches made in other countries. In addition to wrist watches the factory is also making large numbers of stop watches and small travelling clocks.

When the Cheltenham factory was being planned it was decided at the outset that, as no labour skilled in the assembly and adjustment of watches was available, tooling and production methods must be developed to break down complex operations, and wherever possible to introduce progressive individual operations for which staff could be readily trained. This meant that all components would have to be produced within the closest possible tolerances observed in the watchmaking industry. It was considered that with components produced to the closest tolerances it would be possible to train the class of labour available to carry out preliminary assembly of component watch units and to introduce a system of final line assembly which would obviate need for skilled watchmaking knowledge other than a set series of operations. The success with which the firm has carried out its object can now be seen at its works, where all that is required of an assembler is manual dexterity and, at certain stages, a minimum amount of horological knowledge to make small adjustments which are unavoidable.

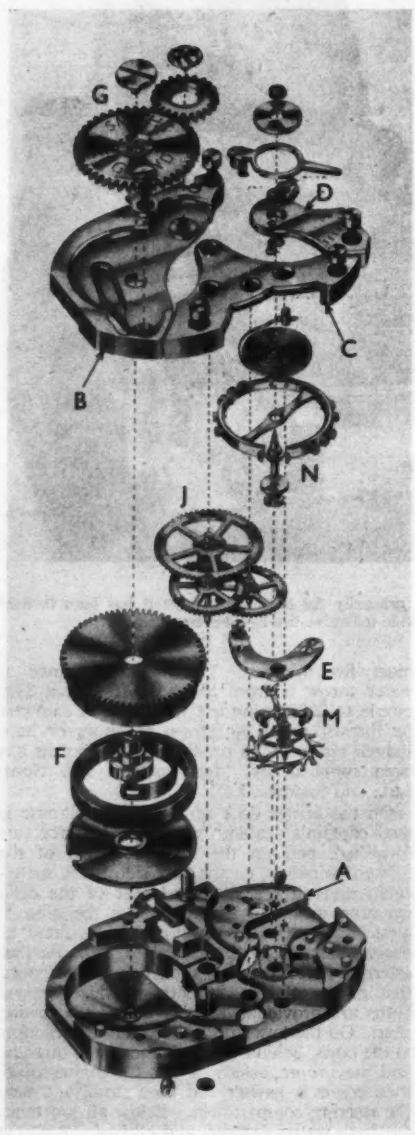
Many of the techniques developed and the machines and equipment used in the watchmaking industry and introduced into the Smith factory were described in some detail in a paper presented to the Institution of Mechanical Engineers in 1952 by Messrs. R. A. Fell and P. Indermuhle. As this paper was largely reproduced in our issue of January 2, 1953, we do not propose to deal in detail with the component production lines at the Cheltenham works, but in the following notes give some particulars of one of the latest assembly lines producing the movements for ladies' 5¼ ligne wrist watches, which were recently developed and introduced by the firm. Before dealing with this line a few particulars of the main plate of the watch will probably be of interest and give some appreciation of the production problems involved to give the highest degree of accuracy which is required both to facilitate assembly and ensure ultimate precision in timekeeping. This plate is 19·70mm (0·7756in) long by 12·80mm (0·5039in) wide and it contains no less than thirty-seven holes ranging from 0·27mm (0·0106in) to 1·20mm (0·0473in) diameter. The manufacturing specification laid down stipulates that a maximum polar error of 0·003mm (0·00012in) shall be maintained over the holes both in this main plate and other plate parts such as the train bridge, pallet bridge, balance cock, &c. Complementary close tolerances have to be observed for the component parts, such as the arbor and staffs, pinions, &c., used in the watch.

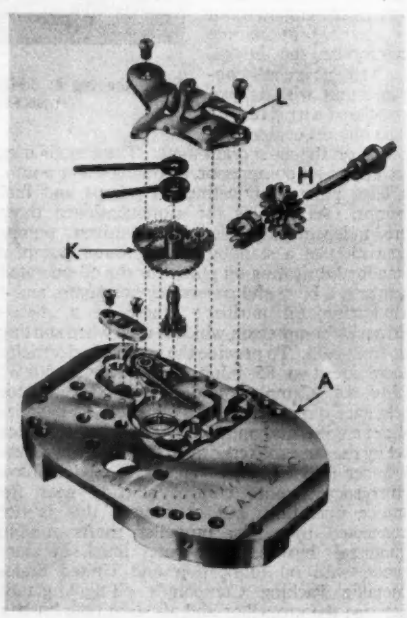
The high standards of tooling and machine setting required for such a degree of precision with small components to be produced in quantity was not the least of the firm's initial problems. Special toolmaking and gauging procedures had to be developed, and for this work a well-equipped toolroom was laid down and suitable staff trained to work consistently to tolerances much tighter than those observed in practically any other branch of industry. Machines suitable for the class of production not available in this country were purchased from abroad.

The assembly line for the 5¼ ligne movement is illustrated in Fig. 2 and on the left side of the shop can be seen a similar line for the assembly of 8¾ ligne watches. At the foot of the line cases, each containing a complete set of components and sub-assemblies, are fed one at a time and at preset intervals on to a moving belt conveyor. This conveyor runs the full length of the line and has the progressive assembly stations set on alternate sides. An operator at each of the fourteen stations assembles a set number of parts and replaces the movement, in its case, on the belt for transfer to the next station. At each station a plough bar slides the movement case off the belt on to the assembler's bench.

A point of interest in this assembly shop is that all the screws are supplied to the stations in magazines designed to facilitate quick handling and accurate location when used with the special tooling. These magazines can be seen in use in the assembly stations which we illustrate. Each magazine consists of a flat disc with rows of holes round its top face, the holes being of sufficient diameter to admit the stem of the screws, leaving them suspended by their heads. The magazines are quickly and easily filled by placing them in a shallow hopper and subjecting them to suction from below. As a heap of screws is then lightly brushed over the surface the stems are drawn down into the holes until they are all filled. This system of filling and using magazines for the supply of screws for assembly is also used in other parts of the factory, where screws and other parts such as pillars and bushes are fitted to sub-assemblies. It saves much of the time normally required to manipulate into a convenient position and pick up such small parts.

At one of the assembly stations illustrated (Fig. 3), where the operator fits the barrel and bridge, the bench equipment includes two sets of screw pick-up and driving spindle devices which are used in conjunction with movement holding and positioning carriers. Each carrier is mounted on slides and a series of stops are used in turn to position the movement on the carrier below the screw driving head with the required holes in line with their screw. The screw driving spindle is slidable in a column, and a vacuum is maintained behind two small holes in the foot of this column to pick up the screws from a magazine carried on a swivelling bracket on the main support. Each time the magazine bracket is swung below the spindle column it is indexed to bring the next screw into position below the column. The column with a screw suspended from its foot is then raised slightly for the





A—Main plate. *B*—Barrel bridge. *C*—Train wheel bridge. *D*—Balance cock. *E*—Pallet cock. *F*—Barrel, mainspring and arbor group. *G*—Barrel ratchet, crown wheel and click group. *H*—Winding stem and pinions group. *J*—Wheel train. *K*—Hour wheel, minute wheel, intermediate wheel. *L*—Hand-setting lever group. *M*—Escapement group. *N*—Balance group.

Fig. 1—Components of 5¼ ligne watch

magazine to be swung back to its position of rest. The column is then pushed right down to register the screw in the hole in the movement on the carrier, the spindle then being turned to drive the screw home.

As already mentioned the assembly of a watch is carried out in fourteen stages on the line, and the principal component parts concerned can be seen in the illustration Fig. 1. All the parts are made for straightforward progressive assembly, and if the slightest difficulty is experienced by the operator at any station in the fitting of a part the complete movement is placed aside for special attention. No adjustments to rectify parts which may have been slightly damaged in handling or transit are permitted on the line, and any form of selective assembly is strictly forbidden.

Movement Assembly Line

At the first station of the movement assembly line the main-spring is fitted in its barrel, and after the barrel arbor and cover have then been assembled and oiled the sub-assembly is tested by end-shaking and for flatness. At the second station the main plate is fitted with the winding stem, sliding and winding pinion, pull-up piece and screw. The wheel train is assembled at the third station, the operations involving the fitting of the centre wheel, third wheel, fourth wheel, and escape wheel with their wheel bridge to the main plate. The train of pivot holes is oiled at the next station. Final assembly of the mechanism is effected at the fifth station where the upper side of the plate is fitted with its carrier pinion, minute wheel, intermediate wheel, hand setting lever, and spring mechanism bridge. At the next station the crown wheel and screw are assembled on the barrel bridge and the bottom end-stone fitted on the main plate.

Two stages of assembly are carried out at the seventh station, a photograph of which is reproduced on this page (Fig. 3). In the first operation the movement is placed in the carrier of the head on the operator's left hand and the barrel sub-assembly is placed in position. The bridge is then placed on the foot of a vacuum pick-up column where it is held by suction and correctly registered over the movement on the carrier. The pick-up column is then depressed to deposit and press the bridge down squarely on its steady pins. The pick-up column is then released and the carrier moved across to its next fixed position below a screwing column where a bridge screw is driven through into the main plate. In the photograph the operator can be seen removing the assembly from the first fixture for transfer to the right hand fixture where the second stage of assembly is effected. In this second stage the movement is placed on the carrier and the ratchet wheel and click (or pawl) are set in position and their respective holding screws of different sizes are inserted, using separate screwing heads at two of the carrier settings.

At the eighth station, the escapement with its lever and bridge are fitted to the movement and the escapement is adjusted. Next the balance cock end-stone is fitted on the regulator assembly and the top and bottom balance jewel holes are oiled. At the tenth station, also shown in one of the accompanying illustrations (Fig 4), the balance is fitted to the cock and this assembly is fitted in the movement, using a screwing head. After the functioning of the hairspring has been tested the movement is passed on to the next station where a final check is made before it is transferred to an electronic timing machine. This machine is to check the instantaneous rate of the movement whilst it is held at various angles, and it gives a reasonable guide to efficiency prior to timing. At this check each movement is provided with a timing slip which accompanies it through all its subsequent checks and is retained as a record at the works. The movement is then, at the thirteenth station, fitted with dummy hands and mounted in a timing case before it is passed to the final station of the line where any small faults are corrected. An inspector then checks that the quality of workmanship is up to the required high standard before the movement is passed out of the line for a series of preliminary performance tests and regulating.

These performance tests are carried out in a section at one corner of the shop. In the tests, the movement undergoes ten individual twenty-four hour tests in different positions on its face, back and at various angles resting on its edge. It is regulated after the third test period, and when the following seven tests have been performed to satisfaction the movement is fitted with its hands and face and put into its case. After casing, six further timing tests are carried out with the watch in different positions and it is finally regulated. In the course of the final tests no watch is passed as satisfactory unless it loses no more than 25 seconds or gains more than 35 seconds in twenty-four hours. It is pointed out by the makers, however, that when a watch is worn on the wrist its timekeeping is much more accurate than the limits required in static testing. If at any stage during testing a movement does not comply with the specified time-keeping requirements it is returned to a special section of the shop for rectification, after which it has to undergo again satisfactorily the complete series of tests.

It is of interest to note that as part of its plan to re-establish the watchmaking industry in this country Smiths Clocks and Watches, Ltd., set up a laboratory in London some four years ago for the design and development of new movements. This laboratory is at present engaged in the development of a new range of high precision wrist watches for navigational use, and it recently completed design work on a new self-winding wrist watch which is now being tooled up for production at the Cheltenham works.

Fig. 2—Assembly lines for ladies' wrist watches on each of which a complete movement is progressively assembled in fourteen stages

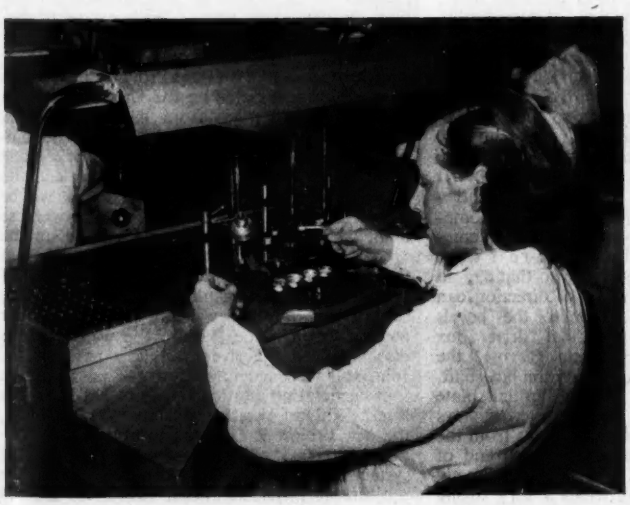


Fig. 3—Two-stage assembly station where barrel and bridge are fitted to movement on left-hand fixture, and ratchet assembly on right-hand fixture

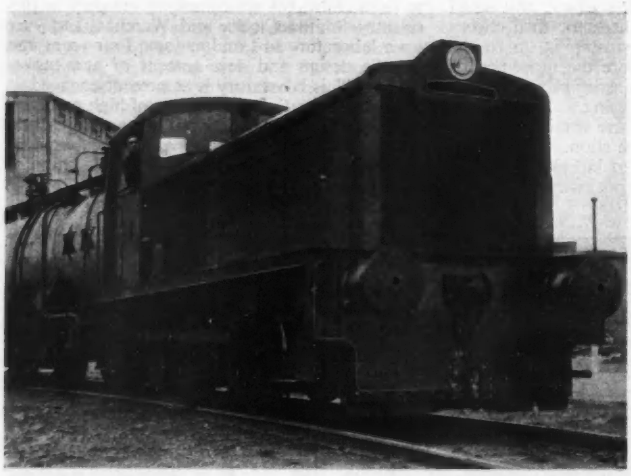
Fig. 4—Tenth assembly station where balance is fitted to the cock and functioning of hairspring is tested and adjusted

Diesel Locomotive with Automatic Mechanical Transmission

TWO prototypes of a diesel shunting locomotive which have been designed and built by Peckett and Sons, Ltd., Bristol, are equipped with fully automatic mechanical transmission. These two locomotives, which are nominally of 200 h.p., have been built for industrial shunting purposes, and the firm is at present developing two smaller versions of 100 h.p. and 150 h.p., respectively. The locomotives can be readily adapted for other classes of work and it is intended to develop the range for higher horsepowers as soon as possible.

We recently inspected one of the prototype locomotives which has been in service for some time in the Portishead works of Albright and Wilson, Ltd., the chemical manufacturers, and is illustrated on this page. This locomotive has an overall weight of 32 tons and has an 0-4-0 wheel arrangement with a wheelbase of 5ft 6in, which enables it to traverse minimum curves of 50ft radius. The 3ft 2½in diameter wheels are driven by connecting and coupling rods from a jackshaft at the rear end. The engine, gearbox and auxiliaries are mounted under a bonnet which has four access doors on either side and large double doors in the roof to facilitate engine maintenance. The cab is of ample size and large windows on all four sides give good visibility from the driving positions, both over the bonnet and to the rear.

The locomotive has a top speed of 13¾ m.p.h. and in bottom gear the tractive effort is approximately 19,000 lb. There are four gear ratios, namely : 4 : 1, 2·54 : 1, 1·57 : 1, and 1 : 1, with a final drive ratio of 10 : 1 from the gearbox to the wheels. These ratios can be varied to suit particular applications, and in the case of the prototype locomotive they give the following speeds : 3·44 m.p.h., 5·41 m.p.h., 8·75 m.p.h. and 13·74 m.p.h., in forward and reverse. One of the new locomotives is fitted with a Gardner "8L3" engine, developing 204 b.h.p. at 1200 r.p.m., and the other with a Crossley "EST4" four cylinder, two-stroke engine developing 220 b.h.p. at 750 r.p.m. By the use of a different ratio in a pair of transfer gears the input shaft of the gearbox is in both cases driven at a maximum speed of 1200 r.p.m. In all other respects the two locomotives are similar. The design has been arranged so that other makes of diesel engine can also be used.



200 h.p. diesel shunting locomotive with automatic mechanical transmission

The four-speed automatic gearbox fitted to the locomotive has been developed by Hobbs Transmission, Ltd., in conjunction with Peckett and Sons, Ltd. In general principle, it is similar to Hobbs transmissions fitted to road vehicles and to certain armoured fighting vehicles and heavy earth moving equipment, though the present application differs considerably in detail. With this form of transmission control of the engine is by means of two levers only, the throttle and the reversing lever, gear changing being completely automatic. The design of the gearbox enables the fitting of an over-riding manual gear lever which will give positive engagement of 1st, 2nd or 3rd ratios. This manual gear engagement can be used to good effect where it is desired to use the resistance of the engine to control a load down long gradients. In the case of a manual change it is only necessary to move the lever to the ratio desired : the actual changing is then accomplished by the various parts of the hydraulic circuit in exactly the same manner as an automatic change.

The gearbox is of compact design, as can be seen in the illustration reproduced alongside, where it is shown fitted on to the final drive unit of the locomotive. The gearbox incorporates a planetary gear train and a set of oil-operated clutches and brakes which drive or hold various parts of the gear train to provide different ratios. A governor valve, built into the box, is controlled by the pressure from an oil pump driven from the output side of the gearbox, so that its position varies with the running speed of the locomotive. The governor valve in turn directs the flow of oil from another oil pump, driven from the input side of the gearbox, to actuate the relevant clutches and brakes for a particular gear ratio.

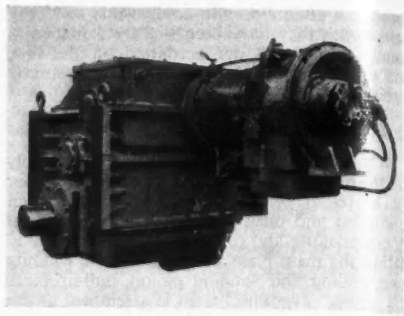
The hydraulic control is designed to give an overlap between the release of one gear ratio and the engagement of the next, so that there is a continuity of traction. Upward gear changes take place at higher speeds than the corresponding downward changes, avoiding the possibility of hunting between two gears on a gradient. A device known as a "trafficating valve" is incorporated in the drive to hold the primary clutch in light engagement when the engine is idling, so that the drive is picked up smoothly as the engine speed increases. All clutches and brake surfaces run in oil so that wear of linings is negligible. Pressure is applied to the clutches and brakes by diaphragms of large area, which enable the use of correspondingly low operating pressures.

Reversing is accomplished by clutching in alternative spiral bevel gears in the final drive, using hydraulically-operated clutches of similar design to those in the gearbox. These clutches are interlocked with the gearbox so that engagement or release can only occur when the engine is at idling speed. It is not necessary, however, for the locomotive itself to be completely at rest when reversing, so that a rapid change of direction can be accomplished. In addition to the bevels and reversing clutches, the final drive box contains double reduction spur gearing, the final gear wheel being mounted on the jackshaft.

The new locomotive has substantial plate frames which are rigidly braced by cross stays on a heavy racking plate which extends from the front of the locomotive to the forward end of the final drive box. This box is bolted directly between the frames and provides a very strong stiffener. The engine is mounted on a welded sub-frame which is bolted on to the racking plate.

Power is transmitted from the engine to the gearbox by a Layrub flexible coupling which also carries a pulley for driving the air compressor. The gearbox, rigidly mounted on a flange on the final drive box, is supported on a bearer at its forward end. The radiator fan and the dynamo are driven from the free end of the engine and electric starters operate on a ring on the engine flywheel.

A fuel tank of 220 gallons capacity is mounted under the bonnet just forward of the driver's cab and doors in the side and roof of the bonnet



Final drive unit with automatic hydraulically operated self-changing gearbox

give very good accessibility for maintenance purposes. A twin cylinder air compressor provides air for the Westinghouse air brake, the horn and the compressed air sanding gear. Brake cylinders on each side of the locomotive operate on the main brake shaft, on which the hand brake also operates independently.

The cab has fixed toughened glass lights fore and aft and sliding windows at the side, whilst full-length doors have windows in the upper half. The controls are duplicated on each side of the control desk, and for actual driving operations only four controls are needed ; throttle, reversing lever, air brake valve and air sanding valve. A hand brake wheel mounted on the rear of the control desk is readily accessible from either side. A panel in the centre of the control desk contains the instruments, which have been kept to the minimum in the interests of simplicity.

Canadian Power Development

THE report of the twenty-eighth annual meeting of Aluminium, Ltd., held in Montreal, Canada, refers to the production setbacks due to water shortage in the Saguenay area and states that the market will absorb the production resulting from the additional capacity which is planned to be added to the Kitimat Smelter over the next three years. With regard to new power development it is stated that the Aluminum Company of Canada, Ltd., is negotiating, with the Government of the Province of Quebec, for development rights on the Upper Peribonka River about 80 miles from Isle Maligne. A preliminary engineering study has been completed and the report mentions that, depending upon the outcome of the negotiations and the success of further surveys, power facilities will be installed a few miles below the Passe Dangereuse dam, which creates a storage reservoir on the Upper Peribonka River. Water will pass from the reservoir through an intake tunnel about 6 miles long to an underground generating station and develop a head of 636ft. After passing through the station, the water will be discharged to the river and flow to Lake St. John and the Saguenay River and pass through four generating stations before reaching sea level. With an installed capacity of 800,000 h.p., the new project is expected to provide an additional 600,000 h.p. to the output of the Saguenay system. The report goes on to say that the project will provide sufficient power for 150,000 tons of additional smelting capacity, including the 22,000-ton smelter building at Isle Maligne, and leave something in reserve.

B.B.C. Engineering Training Centre

In the ten years of its existence, nearly 4000 men and women have passed through the Engineering Training Centre of the B.B.C. at Wood Norton Hall, near Evesham. New buildings have been completed this year, and 200 students can now live there. During 1956, the number attending courses is expected to rise to over 800; there are nineteen instructors and lecturer-demonstrators. Last week members of the Press had an opportunity of visiting the Centre, to see something of the work which is being done there.

TECHNICAL training in the British Broadcasting Corporation began in 1941, when the demand of the Armed Forces for technical manpower was causing a serious shortage of skilled radio personnel. Initially, training was scattered over a number of the regional studio centres and some of the large transmitting stations. Altogether, some 2000 men and women students were trained under this system, which, however, suffered from the disadvantage that personal contact between the instructors was difficult to maintain and that the speed at which students passed through their courses made it difficult to watch their progress after they had left.

At the end of the war it was therefore decided to centralise engineering training in the B.B.C. in an autonomous training department. This was felt to be especially desirable in view of the impending restarting of television. Wood Norton Hall was the obvious choice for the new department. Completed in 1896 for the Duke of Orleans, it was eventually acquired by the B.B.C. in the autumn of 1938 and equipped as an emergency centre. Thus it was already equipped with studios and recording and transmitting apparatus, and, in fact, some technical training had been carried out there during the later stages of the war.

Since 1946 the engineering training department has been in sole occupation. The mansion itself is now used for lecture rooms and offices. Single-storey wooden and brick huts built during the war have been converted into laboratories for dealing with the principles and practice of sound and television broadcasting. When the centre first began, the number of students in residence at any one time was about sixty. It has been the practice from the start to make the centre fully residential. Numbers have steadily grown over the years, and the recent addition of a two-storey block has raised the number which can be accommodated to 200. The new block is a brick-built structure, with accommodation for ninety-six students, equipped with a large common room, and furnished in contemporary style.

In its training activities, the B.B.C. endeavours to develop the skill of the staff and to encourage them to adopt a constructive attitude to new ideas, so as to make them more efficient as individuals and as members of the organisation as a whole. Every attempt is made to avoid duplicating the basic training given by universities and technical colleges, and efforts are concentrated upon the application of basic principles to the equipment and methods used by the B.B.C. There are five main kinds of course, for new entrants, those marked out for promotion, specialists, people converting to other fields, and workshop staff. In addition, training is given to studio managers, who are non-engineering staff responsible for the technical control and balance of sound programmes at the studios. Staff intended for the sound service are trained to operate and maintain the equipment, while in television the greater complexity of the apparatus and increased operational problems have led to a separation of the two functions, students being trained either as operators or as maintenance technicians.

Courses vary in duration according to their nature between one and twelve weeks. Combined twelve weeks' courses are held for technical assistants newly recruited for operation and maintenance in the sound services, and for those who maintain television equipment. Operators in television undergo a six-weeks' course on entry. Promotion courses are held in the various divisions, such as studio technique, recording, transmission lines, &c., and take twelve weeks, the time being equally divided between fundamental principles and their application to B.B.C. equipment. Of the same duration is a course for technical operators in television. Specialist courses of varying lengths (one to three weeks) are arranged from time to time for senior personnel in order to acquaint them with new developments and techniques, or to illustrate the principles underlying established procedure. An example here is the present one-week course in colour television, which has so far been attended by over forty senior officials. In addition, the B.B.C. recruits each year twenty-four graduates to work for two years as graduate apprentices. This scheme, which comprises six months' works training, qualifies candidates for associate membership of the Institution of Electrical Engineers (in all respects other than the requirement of having held a "responsible position"). There are also each year a number of vacation students.

Training at Wood Norton is characterised by the need to avoid the use of higher mathematics in a field the mathematical treatment of which is in parts very complicated. A large amount of the work therefore centres on demonstrations by lecturers and practical laboratory work by the students. Each section of the subject is simplified to the barest essentials and the mathematical treatment is replaced by pictorial explanations, the keynote being the linking of new techniques with the past experience of the student. How successful this method is in practice was demonstrated to the visitors during a tour of the laboratories, where a number of experiments had been set up.

In the general laboratories, a wave synthesiser was shown which allowed the addition to a sine wave of harmonics up to the tenth, each being variable in amplitude and phase. (This instrument has been described in *Electronic Engineering*, September, 1955, page 377.) The result is made visible on a cathode-ray tube. A number of diagrammatic model circuits such as the one illustrated below are used to teach the fundamentals of electric and radio technology. Extensive use is made of standard chassis, which allow a clear view of, and access to, wiring and components.

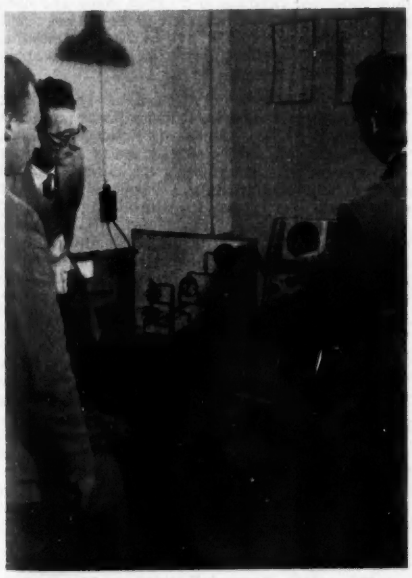
In the optics laboratory was shown, *inter alia*, the functioning of the "zoom" lens, fundamental experiments of tracing the rays in a lens system by multi-coloured light beams, and the separation of a white pencil of light into its constituent colours by means of dichroic mirrors.

Standard magnetic tape recording equipment was used in the acoustics laboratory to demonstrate the need for high-frequency bias of 30 to 100 kc/s in the recording head and the manner of its operation. The analogy between the transfer characteristic of a magnetic tape and that of a push-pull class "C" amplifier was shown. In another experiment a recording was played back to the speaker with a delay time of about one-third of a second. The speaker was completely thrown out of his stride and unable to continue. This striking effect, it was said, had provided the incentive for some fruitful research into the subject of stammering.

Demonstration of model anti-fading aerial. The current distribution is demonstrated with small incandescent lamps

At the basis of all broadcasting technique lies the nature of electro-magnetic radiation. In the aerial hut, apparatus was set up to show the variation in the electric field around a high-frequency coil and various configurations of aerials, using as detectors neon lamps and small incandescent lamps fitted with single twin coils or dipoles. Some of this apparatus is shown in the second illustration. The scaling down in dimensions through the use of very high-frequency made possible the demonstration in the laboratory of such things as short-wave arrays, the phenomenon of "fading" and the principle underlying anti-fading aerials. Another set-up demonstrated the reduction in background noise obtainable by the use of frequency modulation.

The principles of studio design were shown in the acoustics laboratory by means of a ripple tank in which water waves simulated the spread of sound waves in a room. The same means was used to study the behaviour of a microphone, as well as the action of loudspeaker baffles. The functioning of transmission lines, including the



Demonstration of transmitting valve circuits (Scott-connected transformer) in the Fundamentals Laboratory

formation of standing waves, was illustrated by the mechanical analogies of a vibrating string (observed with a stroboflash), and the transmission of sound in a pipe. Stroboscopic examination of a loudspeaker cone with free edge showed the characteristic sub-octave vibration, the same effect being demonstrated by means of lycopodium powder in a cone with clamped edge.

A matter of great importance in television is stage lighting, which is being demonstrated with the help of experimental set-ups of geometrical shapes, dummy heads and figures, and model stage sets. Students check their results by taking photographs. An actual camera channel with monitoring screens is used for the training of operating and maintenance staff and to show the application of lighting principles.

It is not possible to provide students with high-power transmitter facilities, but a 7kW transmitter, operating on 1546 kc/s is available to demonstrate all operational procedures. It is a rebuilt short-wave transmitter used on the Continent during the allied invasion of France.

Six continuity studios are in use at present, and the visitors were able to see continuity training of studio managers being carried out. There is available a control room, which, like the studios, was used during the war as a standby for London, and from which up to eight different programmes can be dealt with.

Farm Implement Factory Extensions

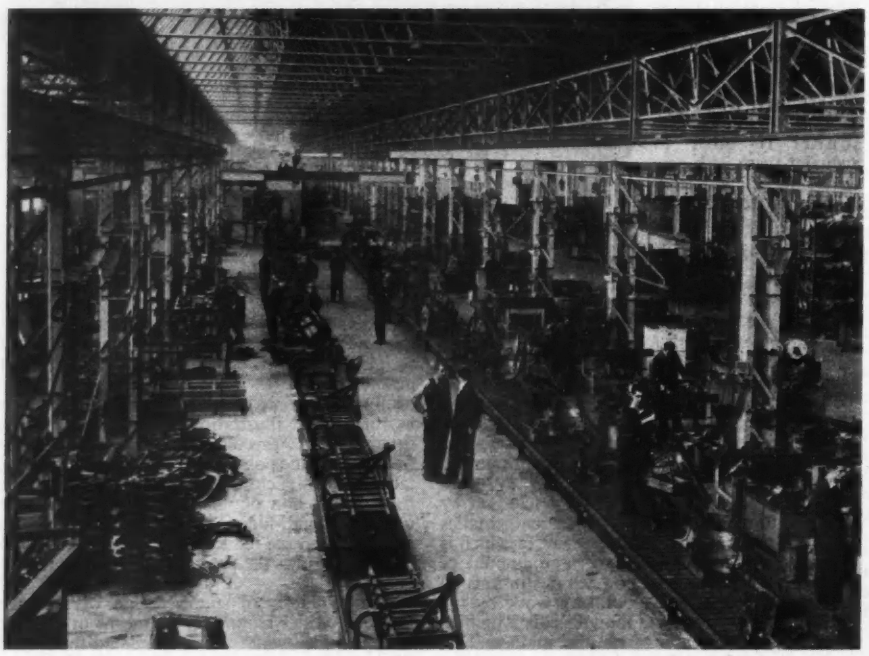
ABOUT eight years ago, Ransomes, Sims and Jefferies, Ltd., acquired a site, covering about 266 acres, at Nacton, a few miles outside Ipswich. The first stage in the development of this site was the building of a modern foundry to supply the general castings required for the company's agricultural implements, electric trucks, and other products, and also for the quantity production of plough shares. As explained in the description of the foundry, published in THE ENGINEER on November 4, 1949, a separate section, consisting of four spacious bays, is devoted to share making.

It is not inappropriate to recall the importance which the firm attaches to the "self-sharpening" property of its plough shares. This quality is imparted by chilling one side of the share blade so that as the unchilled side wears away in work, the chilled face continues to present a keen cutting edge to the soil. The Ransomes' chilled share has a long history. Robert Ransome started business, on his own account, in 1789, as an iron founder at St. Margaret's Ditches, Ipswich, with a capital of £200 and one man to work for him. In 1803, he took out his first patent for a chilled share. It has been said that the actual production of the first of such shares was very much an accident! Robert Ransome had been trying various methods to obtain the result upon which he had set his mind, and one day the molten iron burst out of the moulding frames and ran about the foundry floor. When the metal was broken up for remelting, Ransome noticed that some parts were harder than others, owing to their having come into contact with cold iron, an incident, it is claimed, which gave him his main conception of the chilling process. At the Nacton foundry, the work has been organised in such a way that the plough share and chilled castings section has a capacity of 85 tons, the weekly output of shares averaging 45,000. For the whole foundry, the pattern store handles about 40,000 different wood and metal patterns. At present, another bay of the foundry is being mechanised, and it is intended shortly to build an extension for the production of malleable castings.

During a recent visit to Nacton we were able to see something of the other developments there. After the foundry had been built, Ransomes, Sims and Jefferies, Ltd., set about the erection of a plough and implement factory, in order to transfer that part of its business from the Orwell Works. This new factory includes a machine shop, with a floor space of 52,500 square feet, and an assembly shop with an area of nearly 100,000 square feet. These shops, which incorporate flow production methods, are now in operation for the manufacture of share and disc ploughs, disc harrows, tool bars, potato diggers, cultivators and subsoilers. The assembly shop, a portion of which is shown in our illustration, has two assembly lines, one of them a slat conveyor used for the building of the smaller implements, and the other a drag link conveyor which can accommodate products weighing up to 4 tons. Both lines are served by a 5-ton overhead crane.

These two assembly lines are connected to a common painting line by a transfer conveyor running at right angles to the assembly lines, and containing a wheeled bogie on which the implement to be painted can be transferred. A monorail endless conveyor system approximately 210ft long, travels at a speed of 3·3ft per minute. Complete paint coverage of the work is obtained by flow coat jetting from the bottom, or, when required, from the sides and bottom as well. The flow coating chamber consists of a "Terrazzo" draining slab surrounded by a steel sheet housing, the working sumps to which the return paint flows back being located in a tank room immediately beneath the flow coat chamber proper. The drying oven has a working temperature range of up to 400 deg. Fah., though under normal working conditions the operating temperature is usually between 230 deg. and 250 deg. Fah. The travel time through the oven is 18¼ minutes, and after leaving the oven, the implements are discharged from the load trolleys and are hung on a transfer conveyor which takes them to the despatch department at the end of the works, which has its own loading bays and railway siding. Work has recently been started on an extension of the new factory, to provide another assembly line, an addition to the machine shop, and more facilities for packing and despatch. Plans are also in hand for extensions to accommodate the grindery and heat-treatment sections, and the raw materials store.

Another new building recently completed at the Nacton works is that which houses the photographic department. This building is divided into two sections, one for the barcrographic department and the other for the studio. A barcrographic machine, capable of printing 350 to 400 negatives a day, is used chiefly for the copying of plans and drawings. These are reduced from their original size to half-plate, thereby effecting considerable saving in storage space, as the original drawings are destroyed after being photographed. The studio, with its north wall almost entirely of glass, has been designed for the photographing of agricultural implements and machinery. An electrically operated roller shutter door opens to allow fork lift trucks or lorries to run straight in; they then have their load taken off by an electric crane and deposited on a turntable in the floor, which enables the implement to be photographed in any position. A mobile overhead platform, bearing the photographer and cameras, can move to any position for overhead photographing, and the crane can lift the implement to be photographed to any level required. The architects for the photographic building were Messrs. Hare and Pert, Ipswich, and most of the equipment for it was supplied by E. N. Mason and Sons, Ltd., Colchester.



Implement assembly shop at the Nacton works. The shop has an area of nearly 100,000 square feet, and there are two assembly lines served by a 5-ton overhead crane

Technical Reports

Welded Details for Single-Storey Portal Frames. British Constructional Steelwork Association, Artillery House, Westminster, S.W.1.—Guidance in detailing single-storey welded portal frames, designed under nominally static loading conditions, is given in this report. The frames illustrated are made from rolled steel beams of standard "I" or broad-flanged section, or from welded three-plate members. Stress calculation is not dealt with in detail. The contents falls under the headings of: knee joints and apex joints; valley joints; rafter site joints; bases; and general details of welds. The Association states that its free mailing list has grown to 22,000, so new applicants will have to pay 2s. 6d. for the report.

Stability Functions for Structural Frameworks. By R. K. Livesley and D. B. Chandler. Manchester University Press, 316–324, Oxford Road, Manchester, 13. Price 6s.—In 1953/4 two groups at Manchester were interested in determining the critical loads of elastic rigid jointed structures. One based its methods on relaxation techniques, the other being concerned with the application of the Manchester University electronic computer to structural calculations. Both groups decided independently to use the ratio of the axial load in a member to its Euler load as the independent variable in determining the stability functions.

The tables in this pamphlet are an example of collaboration between the groups. The computer approach does not require the use of tables, the necessary functions being generated as required in the calculations, but the ease with which function tabulation can be carried out on an electronic machine has led to the production of these tables. Dr. Livesley is responsible for the main body of tables. The preliminary text and the treatment of gusset plate effects are by Dr. Chandler.

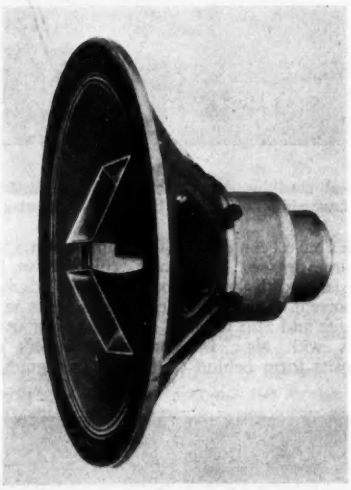
As the functions are still not familiar to engineers (the *m*, *n*, *o* functions being tabulated here for the first time), examples have been given of some of their present methods of use. The authors consider, however, that the tables should be thought of in the same way as, say, trigonometrical tables and that their use will not be limited to the particular types of examples shown.

Co-Axial Dual-Channel Loudspeaker

THE loudspeaker illustrated here was developed by the British Thomson-Houston Company, Ltd., Rugby, for the auditorium sound channel of the first "CinemaScope" installation in Europe. It is now available to the general public and should appeal to the enthusiast who is interested in high-fidelity reproduction.

The loudspeaker (designated "K10A") is a co-axial dual-channel equipment having an 18in diameter l.f. cone assembly with a twin-mouthed h.f. horn mounted in the centre pole and coupled by a special form of phase equaliser to an anodised aluminium alloy diaphragm. To divide the high and low audio-frequency energy from the amplifier an external filter unit having a cross-over frequency of approximately 1700 c/s is used.

A sectional view of the loudspeaker is reproduced below. The h.f. metal diaphragm electrodynamic unit is designed for high stability, good power handling capacity (about 20W audio) and low distortion levels. By extending the h.f. horn in front of the centre l.f. diaphragm distortion due to intermodulation has been kept to a relatively low level whilst still maintaining the good "presence" which characterises co-axial sound sources, even when being operated close to the listener.



Coaxial dual-channel loudspeaker with 18in l.f. cone assembly and twin mouthed h.f. horn

The twin flare of the h.f. horn has a wider polar characteristic in the plane through the line joining the mouth centres than in the plane at right angles to that line and, accordingly, utilises the high-frequency sound energy to the best advantage for normal listening conditions. The "pepper pot" construction of the end of the centre pole provides a mechanically stable and acoustically effective phase equaliser designed to minimise turbulence and interference of the phase of the sound pressure at the higher audio frequencies, which frequently occur due to variation of path lengths from various portions of the diaphragm to the throat of the horn. The horn flaring nearly conforms to the standard expression

$$A = A_0 e^{mx},$$

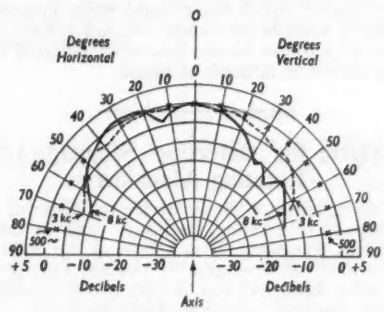
where

A = area at mouth,
A_0 = area at throat,
e = 2·718,
m = flaring constant,
x = distance from throat to mouth,

giving a flaring constant which allows for effective coupling of the diaphragm to the air down to a frequency of approximately 1200 c/s. With a 3in by 3in dimension for each mouth of the twin horn the low-frequency cut-off due to the mouth dimensions is also in the same region.

These factors determine the choice of the cross-over frequency of approximately 1700 c/s, together with the narrowing polar diagram for an 18in cone assembly above this frequency. The frequency chosen allows relatively small components, particularly air-cooled chokes to be used in the filter circuit. The B.T.H. filter unit, "G2A," is a two-section inductive/capacitance filter with an attenuation of 12 db per octave at cross-over.

A tandem permanent magnet assembly is used. The circumferential surface of the centre plate provides a good position for supporting the overhanging mass of the speaker unit when mounted in a cabinet. Because of the separate air gaps for the l.f. and h.f. sections of the magnet assembly, and the low reluctance common flux path in the centre plate, electromagnetic intermodulation is negligible. "Alcomax 11" magnet material is used, giving gap flux densities as follows :—



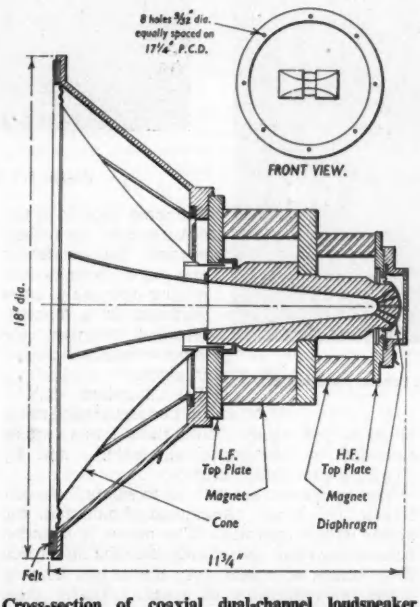
Polar diagram showing characteristics of K10A coaxial dual-channel loudspeaker

	L.F.	H.F.
Gap flux density (gauss) ...	14,300	12,700
Total flux (Maxwells)... ...	285,000	48,000

These flux values, in conjunction with the moving coil and diaphragm details, are chosen to provide a balanced output from the relatively high-efficiency horn type h.f. unit and the direct-radiator l.f. diaphragm.

The conventional frequency/intensity response curve, whilst serving as a useful guide of performance under known comparable conditions, can be misleading with regard to the expected subjective results when a listening test is carried out. A method of delayed resonance response measurement has therefore been used as a method for determining the frequency response characteristic of the speaker. This is based on the method described by Mr. D. E. L. Shorter in the *B.B.C. Quarterly*, October, 1946. A train of waves having a square envelope of a selected frequency is applied to the moving coil of the speaker, and the resultant sound intensity is measured at the time of the signal and at suitable intervals after the electrical input has ceased. Measurement is carried out by a microphone with amplifier and a suitable presentation measuring unit, such as a cathode-ray oscilloscope. Satisfactory tests have been carried out by the manufacturer on the K10A loudspeaker under conditions where the reflected energy from the surroundings was so low that it did not appreciably affect the readings.

A "Bass Reflex" cabinet (having an internal air volume of 7 cubic feet and grill which is relatively non-absorbent to the high audio frequency output) is suggested as a suitable mounting to match the response of the loudspeaker, particularly at the bass end of the audio range.



Cross-section of coaxial dual-channel loudspeaker showing arrangement of h.f. horn and diaphragm

Automatic Announcer

AN automatic announcer, which can reproduce any one of twenty-five recorded announcements or signals for relaying over a loudspeaker system, has been developed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It was originally developed for British Railways (Eastern Region) and first installed at Stratford Station. In this installation the platform announcements for passengers are automatically initiated by the trains themselves, first as they approach the station and then again as they come to a standstill at the platform. Similar equipment is now available for general industrial use and can be applied in any situation where numbers of routine broadcasts have to be repeated fairly frequently.

Automatic announcer. At the top is the monitor and below it the twenty-five button selector panel and the pre-amplifier. Below the playback head and the tape are the track selector relays and power pack

The messages are recorded side-by-side on a special loop of magnetic tape, 3in wide, and the appropriate message is selected by push button when required. To make the system fully automatic, particular announcements, such as shift changes, meal breaks or other messages, can be triggered off by a master clock mechanism with out the need for any human attendance. The push buttons can be mounted remotely from the instrument so that announcements or emergency calls, such as fire alarms, can be initiated from other parts of the premises.

The paper-backed magnetic tape used is made in the form of a continuous loop, 3½in wide, which normally lasts thirty seconds, but special loops can be supplied for any duration lasting between ten seconds and about four minutes. A short length of metallic foil is spliced in at the point where the two ends of the loop join. At the end of the announcement the foil completes the circuit between two contact fingers, automatically switching off the mechanism and preparing it for the next announcement.

The loop of tape is moved past the playback head at a steady speed of 7½in per second by a mechanical drive system powered by a 1/20 h.p. motor. The motor is dynamically balanced and resiliently mounted at the rear of the panel, the drive being transmitted by a flexible shaft, nylon helical gears and two large-diameter pulleys coupled by a nylon-loaded fabric belt. On selecting the required announcement, either by push button or by remote control, the playback head is moved to the correct tracking position by a specially designed mechanism. Control of the tape motor and the head positioning device is effected by a twenty-five-position rotary selector switch associated with seven switching relays mounted under detachable covers. As the tape is played it passes through a guide into a "Perspex"-fronted casket, where it falls naturally

into folds or convolutions. The use of a continuous loop of tape eliminates the need for spools or rewinding.

The three basic units forming the complete equipment are designed in panel form suitable for mounting on a standard G.P.O. type rack frame; they are the announcer unit, the pre-amplifier and monitor unit, and the power unit, consisting of a heavy duty transformer and rectifier assembly providing 50V d.c. and 24V a.c. A demonstration version of the automatic announcer is illustrated on the previous page.

Microwave Beacon

THE radio and radar division of Elliott Brothers (London), Ltd., has developed a new microwave course beacon as a navigational aid for small craft, and the company has been giving demonstrations of the new equipment at a number of harbours during recent weeks. Since the war the use of microwave radar as an aid to ship navigation has become almost universal, and the X-band search radar is a recognised fitting in merchant vessels. However, such equipment requires a considerable amount of space and power, neither of which are available on fishing vessels and similar small craft, so that the gear is unsuitable for this size of vessel.

The main problem of small craft is the approach to a small harbour under conditions of poor visibility, and the new beacon has been designed to meet this requirement. It combines reliability with robustness and the system, which operates on the Loran system of overlapping beams keyed with complementary audio signals, consists of a transmitter which requires electric power and a small battery operated receiver. The X-band (3cm wavelength) transmitter measures 2ft by 2ft by 2ft, weighs about 80 lb and is sited at a point at the harbour entrance while the pretuned receiver, measuring 5in by 5in by 5in and weighing 20 oz, is carried in the boat. The output of the transmitter, consisting of a magnetron modulated at 1000 p.p.s. with pulses of about 0·3 microsecond duration, is fed to twin aerials, one of which produces the Morse letter V and the other the letter B. The two main lobes are each 60 deg. wide and the equi-signal beam is between 0·5 deg. and 1 deg. wide, which allows a lateral discrimination

Fishing vessel shown entering port and homing on a beacon mounted at harbour entrance

of 15 to 20 yards at 1 mile range. Reception covers an arc of 120 deg. and up to 7 miles distant. A horn feeding a crystal detector, followed by a transistor audio amplifier, are incorporated in the receiver, which is powered by a standard 4·5V flash-lamp battery, and can be held by hand or fitted in a deck mounting. The unit is used in conjunction with headphones.

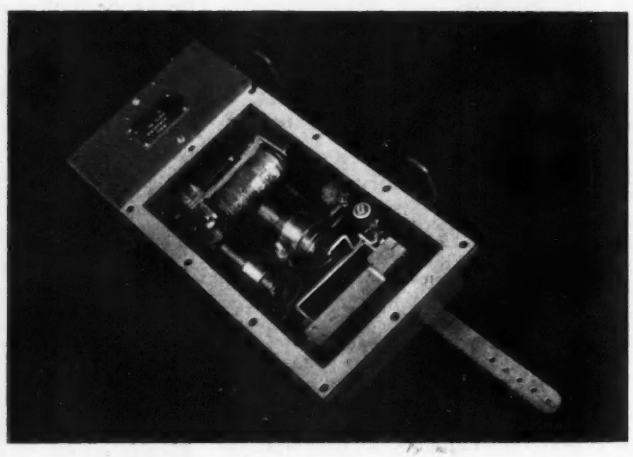
For operational purposes the transmitter is mounted at a suitable point and the aerial system lined up with the most suitable approach course. When approaching harbour the receiver on the boat is switched on and the boat is to port if a "V" signal is picked up or to starboard if the "B" signal is received; then the appropriate helm can be used until a steady note indicates that the equi-signal path is reached. The craft is then crossing the most suitable approach course. The receiver is also directional, the loudest signal being heard when pointing directly towards the transmitter, and so the ship can set a course for the beacon as indicated by the maximum strength of signal.

Alarm for Detecting Stoppage of Rotating Machinery

WE illustrate a simple device for detecting a stoppage of rotating machinery used in continuous processes. It is known as the R.S.D. unit and was developed by Londex, Ltd., 207, Anerley Road, London, S.E.20, in collaboration with Imperial Chemical Industries, Ltd. It uses a principle pioneered by I.C.I., Billingham Division, where the original R.S.D. units built by the company have, we learn, given satisfactory service for over two years.

The equipment consists of a cam follower arm attached to a rocker shaft which carries an insulated bar operating a set of contacts. The rocker shaft enters the casing through a bonded rubber bush which acts as bearing and return spring and provides a hermetic seal. The drive that is to be monitored by the R.S.D. unit is fitted with a cam whereby the cam follower arm is lifted once or more during each revolution of the drive. This periodic movement of the arm causes the contacts to be operated continually and, by means of a condenser circuit, to energise a relay. Any stoppage of the drive stops the operation of the contacts, resets the relay and operates an alarm circuit.

In the accompanying illustration the cover has been removed from the main compartment of the protective casing to show the cam follower arm, the rocker shaft and lever and the operating contacts at the right hand of the casing.



Alarm for detecting stoppage of rotating machinery

The main relay is at the other end of the casing, beyond the condenser and dry cells. Adjoining the main compartment is a separate terminal chamber, the cover of which is shown in place.

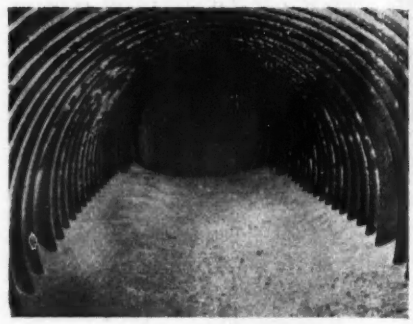
The standard R.S.D. unit covers a speed range of 30 to 300 r.p.m. Both these limits can be extended by altering circuit values, and by changing cam characteristics.

The equipment has a "fail to safety" characteristic, i.e. if any component should fail, the alarm circuit operates. The alarm is sounded between two and six seconds after the monitored drive ceases to rotate. An alarm can be provided on reductions of speed. Under these conditions an intermittent alarm will be given.

The life of the contacts is stated to be about 100 million operations, and contact replacement is simple. The rubber bush provides a restoring couple of approximately 5 oz-in and the follower arm movement at 5½in is $\frac{3}{16}$in with a safe overtravel of $\frac{1}{4}$in.

Furnace Baffle

FOR a number of years Combustion Equipment, Ltd., of 61, Belsize Lane, Hampstead, London, N.W.3, has been developing a furnace baffle for use in shell boilers. The Mark IV baffle has been evolved by the company in collaboration with the British Coal Utilisation Research Association. Different forms of



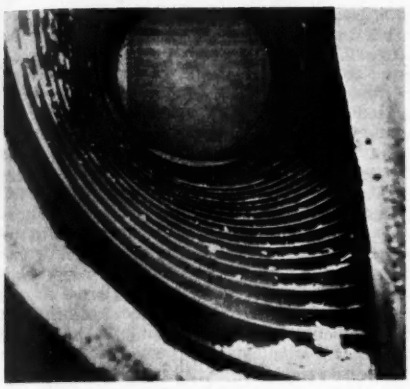
Normal condition of furnace flues in a coal-fired Lancashire boiler after 1000 hours' steaming

baffles have been devised from time to time, with varying degrees of success, to improve heat transfer and the present baffle has been designed to prevent the build up of dust deposits in the furnace and also to assist in mixing combustible gases with air. In Lancashire boilers dust deposits form behind the bridge and gradually spread over the length of the furnace tube, thus causing an increasing reduction in heat transfer. The amount of such deposits can be seen in our illustration, which shows the condition of a coal-fired Lancashire boiler furnace tube after 1000 hours' steaming, a condition which can result in as much as an 8 per cent loss in efficiency. It has been to eliminate these grit deposits and so reduce fuel costs that investigations into the best form of baffle and its position have been undertaken. A simple and relatively inexpensive baffle has been evolved as an aid to fuel economy and smoke abatement and it can be used with Lancashire, Cornish, Economic and marine shell boilers when fired with most fuels, using any form of grate or firing equipment. The result of fitting a baffle can be seen in our second illustration, which shows the condition of furnace tube, previously illustrated, after 1400 hours' steaming.

As experience has been gained and data

accumulated the baffle has undergone changes in design and the latest Mark IV unit consists of a number of high-alumina firebricks, supported by a central pedestal, specially shaped so that they can be rapidly assembled and installed in position. This latter is determined by a number of factors, including the pattern and size of boiler, the fuel used and method of firing and the grate loading.

In coal-fired boilers the gases tend to become stratified, with combustible gases concentrating in the vicinity of the crown and with the air being near the bottom of the furnace tube. The fitting of a baffle at a predetermined position will cause a marked increase in gas turbulence and, by forcing the combustible gases downwards to mix



Condition of furnace tube after 1400 hours' steaming with Mark IV baffles fitted

with the air, will result in a more rapid rate of burning and a corresponding earlier heat release, an effect which is of importance with Economic boilers. Another effect resulting from the deflection of gases is that most of the grit, which is normally deposited behind the bridge and along the furnace tube, is swept away by the increased gas velocity and deposited elsewhere at points where it does not adversely affect heat transfer or efficiency. Boiler efficiency is also improved by the baffles absorbing part of the sensible heat in the flue gas and radiating it to the furnace walls. Other benefits claimed as the result of fitting baffles are increased steam output, less soot in the smoke tubes of Economic boilers, and less back-end trouble where due to high gas temperature.

For oil-fired Lancashire and large Economic boilers the company recommends that Mark IV baffles are fitted so as to form with other brickwork, an oil firing furnace which will give a longer gas path, create greater turbulence, cause increased draught loss, and modify acoustic characteristics. These changes, it is stated, will increase the speed of heat release and reduce exit gas temperature and probably improve CO_2 percentage. Other effects from improved combustion will be a reduction in carbon deposits in the furnace and soot emission from the chimney stack, and less soot deposited in the smoke tubes and back ends of Economic and Scotch marine boilers.

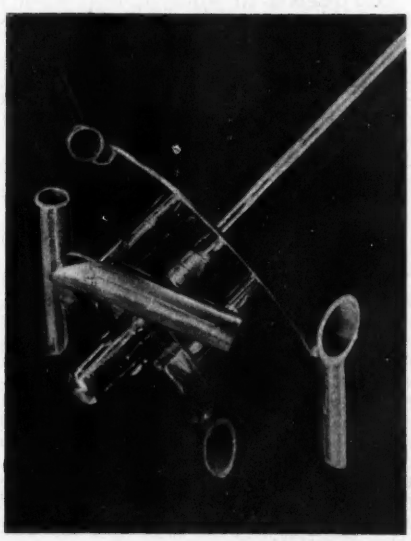
Combustion Equipment, Ltd., states that during the last three years the company has installed over 1000 Mark IV baffles in shell boilers and that operational experience has shown that the fitting of baffles has given the following results. There has been an increased draught loss up to 0·2in water gauge which indicates that when the draught is weak baffles cannot be fitted successfully. The increased gas turbulence created has caused faster burning and earlier release of heat, and the deflection of the gases has prevented the accumulation of grit and thus the reduction of heat transfer when the fuel used is coal. The increased gas turbulence and the deflection of gases, acting separately or in combination, reduced the gas temperature downstream from the baffle by 200 deg. to 300 deg. Fah. in the combustion chambers of Economic boilers, or 150 deg. Fah. in the side flues of Lancashire boilers, the actual amount varying with operating conditions. A fourth effect noted was the elimination or reduction in pulsation in oil-fired boilers.

Where the load on the boiler is very high and the fuel contains a large proportion of fines and the ash a high proportion of iron, the company suggests that it would be advantageous to install a steam flue dust blower, in addition to a Mark IV baffle. The blower, which should be operated for one minute twice a day, would serve to keep the dusty deposits, resulting from the conditions of loading and fuel used, to a minimum between bridge and baffle.

Mixing Machine

A NEW design of machine for the mixing of liquids of varying viscosities, mixing of liquids with solids, or the preparation of emulsions in the chemical, oil, paint, food processing and other industries, has been developed by Plenty and Son, Ltd., Newbury, Berks. In this machine a mixing unit, known as an "Impelator," is suspended from the shaft of an electric motor and submerged in the media to be mixed.

The "Impelator," which can be seen in the accompanying illustration, consists of a number of small conical-shaped tubes mounted round the peripheries of discs. One set of discs is fitted on the bottom of the vertical rotating shaft, and a second set can be adjusted and fixed at any required point above on the same shaft in accordance with the height of the vessel containing the media. Other sets of discs can be added if required. The conical tubes on the discs are set at such an angle that, as they rotate, they create an upwards and a downwards current which increases turbulence and flow in the vessel. During rotation the liquid, or mixture of solids and liquid, which passes through the tubes impinges on the already moving bulk of the mass. This produces a rapid shearing action between the particles of each of the materials and results in a well dispersed and homogeneous mixture of minute particle size. The downwards flow imparted by the tubes on the lower disc prevents the formation of a sediment at the bottom of the mixing vessel.



Shaft of "Impelator" mixing machine which carries two sets of discs fitted with conical tubes. As the shaft rotates the tubes create turbulence in the media being mixed

The mixers are made in a number of standard sizes. A laboratory machine is mounted on a pedestal on which it is adjustable for height and angle to suit different vessels and it is driven by a variable speed motor of from 600 r.p.m. to 2000 r.p.m. Other sizes of the machine are built for capacities ranging from 20 to 3000 gallons according to the viscosity of the medium to be mixed and the shape of the vessel used. The parts of the mixers in contact with the products being mixed can be made in various materials or protectively treated.

Small Diesel Marine Engines Using Class "B" Fuel

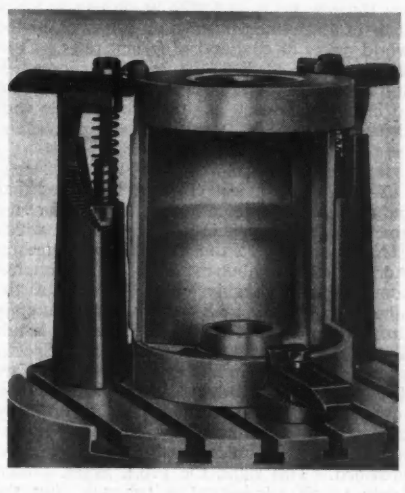
A GROUP of nine Mark 9–E6 Russell Newbery marine auxiliary units has been operating for periods ranging from fifteen to twenty months on class "B" diesel fuel, and experiments involving over 8000 hours' running on each engine was carried out on three Scottish vessels operating a ferry service. The company states that experience has shown that the four main requirements to achieve reasonable performance on class "B" fuel are: the precleaning of the fuel to avoid nozzle and fuel pump wear; the maintenance of a reasonable load, 70 per cent of full load being the minimum; the maintenance of a water jacket temperature of about 165 deg. Fah. by adopting fresh-water cooling, and the use of a supplement lubricating oil associated with oil filter cleaning and a regular oil change period. The cylinder liner wear and related hours of running are stated to be as given in the accompanying table.

Engine	Hours	Liner wear, maximum	
		Forward and aft, in	Port and starboard, in
First ferry			
No. 1	8113	+0·002	+0·004
No. 2	7730	+0·003	+0·004
No. 3	5471	+0·002	+0·004
Second ferry			
No. 1	5286	+0·003	+0·005
No. 2	6104	+0·003	+0·005
No. 3	5840	+0·003	+0·004
Third ferry			
No. 1	3760	—	+0·001
No. 2	4287	—	+0·0015
No. 3	3793	—	+0·001

Machine Clamps

Two sizes of a new form of work clamp, now being marketed by the Rockwell Machine Tool Company, Ltd., Edgware Road, London, N.W.2, are illustrated below. The clamps are designed for use with tee-slotted tables and are made in sixteen sizes for holding work pieces up to 15½in high.

In the cast base of these clamps there is a helical "staircase" consisting of small steps extending round the axis of the centrally disposed clamping bolt, which is made of heat-treated steel. This staircase supports the lower stepped end of a clamping strap supporting member, which can be rotated about the bolt. The offset clamping strap is carried in a groove in the support member, along which it is longitudinally adjustable. If required, the clamping strap can be reversed in the support to suit the shape of the components to be mounted on the table.



Stepped adjustable helical clamps holding a component on a tee-slotted table

A compression spring is fitted on the bolt between the base and the clamping strap assembly to facilitate height adjustment.

Industrial and Labour Notes

Coal Prices

The National Coal Board has announced that, as from to-day, June 1st, the inland prices of all its coals must be increased by 8 per cent, which is, on average, about 6s. a ton. The Board has reached this decision after reviewing its prospective income and expenditure for the remainder of this year and for 1957. The price increase is expected to yield additional revenue of about £35,000,000 in 1956 and £61,000,000 in 1957. This, it is stated, should enable the Board to reduce, though not eliminate, its accumulated deficit which, at the end of last year, amounted to nearly £37,000,000. The Board has estimated that, despite a surplus in the first quarter of this year, 1956 will show a substantial deficit and 1957 a much larger one, unless there is a price increase.

In a review of its principal financial commitments, the Board emphasises that it must pay wages sufficient to attract and hold the men the coal industry needs. Between March, 1955, and March, 1956, the official index of weekly wage rates rose by 9 per cent, and the Board's estimates indicate that its wages bill this year is likely to be 8 per cent higher than it was last year. The Board has also had to take account of increasing expenditure on safety, health and welfare measures, and of the cost of reconstruction programmes. On this latter point it says that more new sinkings and colliery reconstructions must be started each year and that only a few of those already in hand are likely to be completed by the end of 1957. Capital charges for interest and depreciation must be met meantime, and operating costs increase while output continues from pits during reconstruction. Other costs about which the Coal Board is concerned include higher local rates, the full effect of higher national insurance rates, and such items as the increased postal and telephone charges. Then there is the increased expenditure on research of various kinds and on education and training. Furthermore, the Board must make provision for the additional cost (estimated at £5,000,000 a year) of the new right for compensation for subsidence damage which the Government is proposing. In its review of expenditure, the Board has, of course, considered the effect of coal imports. On this point it says that although the tonnage being imported at present is lower than in 1955, there have been increases in the world prices of coal and of freight rates. Consequently, the effect on the Board's finances will still be considerable, since imported coal is sold to inland consumers at prices comparable with British coal.

Procedure at Public Inquiries

The Federation of British Industries has published some notes on proposals for the amendment of public inquiry procedures, which it has submitted to the Franks Committee on Administrative Tribunals. The Federation has commented favourably on a number of the administrative tribunals with which manufacturing industry is concerned, such as the Lands Tribunal, the Transport Tribunal and the Special and General Commissioners for Income Tax. These bodies, the F.B.I. considers, discharge their respective functions with impartiality and efficiency. On questions of law, a right of appeal to the High Court against their findings is provided. This right, the F.B.I. urges, should apply to all administrative tribunals, but the F.B.I. sees no benefit in transferring the many technical issues decided by these tribunals to a court of law.

The Federation goes on to say, however, that industry is not altogether satisfied with the procedures for public inquiry held under planning law and other forms of technical legislation. Where, for example, a decision of a local planning authority is being contested, the appellant is not always fully aware of the case he has to meet. The F.B.I. says that, both before and after the public inquiry, the attitude of other government departments may prove significant in influencing the Minister's decision; yet officials of government departments are not always put up at the inquiry to state their views and to be cross-examined by the appellant or his advisers. Moreover, the Federation's view is that the facts found by the inspector or commissioner holding the inquiry should be published. Such publication, it says, enables the appellant to satisfy himself that a proper appreciation of the arguments advanced at the inquiry has been made, and to supplement or controvert the facts if the report is inadequate or incorrect. The F.B.I. adds that it is opposed to judicial review of the administrative decision taken by the Minister after a public inquiry, though it thinks that the High Court should have power to consider questions of law raised at the inquiry or any alleged violation of the principles of natural justice.

The F.B.I. has also pointed out that inquiries held to consider objections to the confirmation of by-laws are causing concern. This, it says, arises from the practice of Ministries issuing model by-laws as a guide to local authorities. The danger, the F.B.I. feels, lies in the fact that local authorities adopt the model completely, without establishing that there is a special need for it in the area to which it is to apply. Finally, the F.B.I. puts forward some views about inquiries concerning the compulsory acquisition of land. It says that where such inquiries are held "the canons of fair play to the owner in danger of losing his property should always be strictly observed."

Overseas Trade

In its comments on the final figures of Britain's overseas trade in April, the Board of Trade says that there was little change in the general trend. The visible trade deficit, at £57,300,000, was somewhat higher than in the two preceding months. But the increase, it is stated, was caused mainly by the effect on exports of April being a shorter working month (twenty-four days). The value of imports in April was a little lower than in March. In the first four months of this year, the average monthly deficit of £56,000,000 was £16,000,000 less than the rate for 1955 as a whole, but was still £6,000,000 higher than the average for 1954.

The value of United Kingdom exports in April was £256,400,000, which was £15,000,000 less than the record figure for March, when there were two more working days. Over the first four months of this year, the value of exports was about 9 per cent higher than in the comparable period of 1955; rather more than half of that increase being due to a rise in volume and rather less than half to higher prices. The commodity composition of exports in April, the Board of Trade says, showed a further move towards a higher proportion of metal and engineering products and a further decline in the share of textiles.

Another observation made by the Board of Trade is that, in April, exports to North America reached a value of nearly £34,000,000. But the shipments to the U.S.A. included £1,250,000 worth of silver bullion, representing the first instalment of a repayment of 88,000,000 ounces of silver borrowed during the war. This repayment will take place over the next twelve months and is expected to amount to about £30,000,000 altogether.

Railway Staff Negotiating Machinery

The "machinery of negotiation" for railway conciliation and clerical staff has been altered very little since 1935. Certain revisions have now been agreed upon by the British Transport Commission, the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs Association. The new arrangements will become effective on July 1st.

The existing machinery for joint meetings at national level provides for discussion between the Railway Staff Conference (representing railway management) and the trade unions concerned. This procedure is now to be replaced by a Railway Staff Joint Council, consisting of four sections, namely, salaried, locomotive, traffic and general. Questions affecting the classification of salaried posts, which formerly could not be carried beyond reference to the general manager, can, under the new procedure, be taken as far as the Railway Staff Joint Council. The Railway Staff National Council, which is a joint body of management and trade unions, and which constitutes the next stage in the machinery, will in future deal only with major issues after failure to agree at the Railway Staff Joint Council.

At present, terms of reference to the Railway Staff National Tribunal (which is an independent arbitration tribunal) must be agreed between the parties. In future parties desiring to refer an issue to the tribunal will notify the opposing parties. Another alteration which has been agreed is that only staff who are members of a union which is a party to the "machinery agreement" will be eligible to make nominations for or be nominated to departmental committees and sectional councils. The minimum age for participation in elections to such committees and councils, which is now twenty, is to be reduced to eighteen. Finally, it has been agreed that a matter within the scope of the negotiating machinery may not in future be referred to any person or body outside (e.g. to a Minister or Government department) until it has been considered at all stages of the machinery for which it is eligible.

Capital Investment

In a statement circulated with the annual report of British Insulated Callender's Cables, Ltd., the chairman, Mr. W. H. McFadzean, expresses "grave disquiet" about the slowing down and "indeed, almost discouragement" by the Government of capital expenditure by industry. The necessity of curtailing consumption in this country is fully appreciated, Mr. McFadzean says. But, he adds, the last kind of expenditure to be curtailed is surely that which will make a substantial and essential contribution to two most vital and closely related problems, namely, the achievement of a real increase in productivity, and the capture of a far greater share of world markets. Industry can and must do a lot for itself, the statement continues, but the electrical industry, with its constant development of new and improved techniques, must be fearless in its capital expenditure if it is going to hold at bay and beat its substantial and numerous overseas competitors.

Wage Accounting by Electronic Computer

A study group, representing the National Physical Laboratory, the Treasury, and the Ministry of Pensions and National Insurance, is investigating methods of doing clerical work with electronic computers. Its first report, entitled *Wage Accounting by Electronic Computer*, has just been published (H.M. Stationery Office, price 2s. 6d.).

The report gives detailed information which is applicable to all forms of payroll work. It deals generally with payroll calculations, and with one particular case which is analysed in considerable detail. In the scheme considered an existing high-speed computer with some modifications is employed. It calculates each worker's overtime, finds out how much income tax he should pay, and deducts that and his national insurance contributions from his gross wages. The computer, the report shows, will also deal with voluntary deductions for sports clubs and the like and, in addition, "remembers to tell the authorities a fortnight before a man's pay increment is due."

The report shows that a scheme of the kind examined can be economic, using present-day payroll procedure, and it estimates the costs when applied to various payrolls. It is stated that the calculations for a staff of 3400, paid weekly with overtime but not piece-work, can be done in one hour, but that forty-three man-hours of labour are required to feed and extract the information.

Free-Piston Gas Generators at Cherbourg

THE present design of free piston gas generator was developed by Pescara from earlier units and the work continued under the direction of R. Huber. An experimental vertical unit having a diesel cylinder of 12in bore was running in the Alsthom works at Belfort in 1938, but further development was abandoned owing to the war. However, at the works of the Société Industrielle Générale de Mécanique Apliquée (S.I.G.M.A.) two other designs of free-piston gas generators were evolved, and the larger one is now known as the G.S.-34. This unit has a bore of 13·4in and a gas horsepower rating of 1250 and, in combination with a gas turbine, has formed an engine set which has been increasingly used for a number of industrial applications. These include pumping sets, air compressors, railway traction, main propelling machinery for naval and merchant ships, and the generation of electricity. The Renault gas turbine locomotive powered by a free-piston gas generator was described in our issues of March 6, 1953 and April 29, 1955, and a portable air compressor was mentioned in our columns on March 6, 1953, while in our issue of March 19, 1954, particulars were given of coaster "Catenac," which had main machinery consisting of two G.S.-34 gas generators and two gas turbines driving a single shaft through reduction gearing.

In 1937 Alan Muntz and Co., Ltd., acquired from Ante Compresseurs Pescara (A.C.P.) the exclusive rights to the Pescara free-piston patents for Great Britain, the British Commonwealth and Egypt, and in our columns of April 6th of this year we recorded the formation of Free Piston Engine Company, Ltd., as sub-licensees in addition to C. D. Holmes and Co., Ltd., and Smith's Dock Company, Ltd.

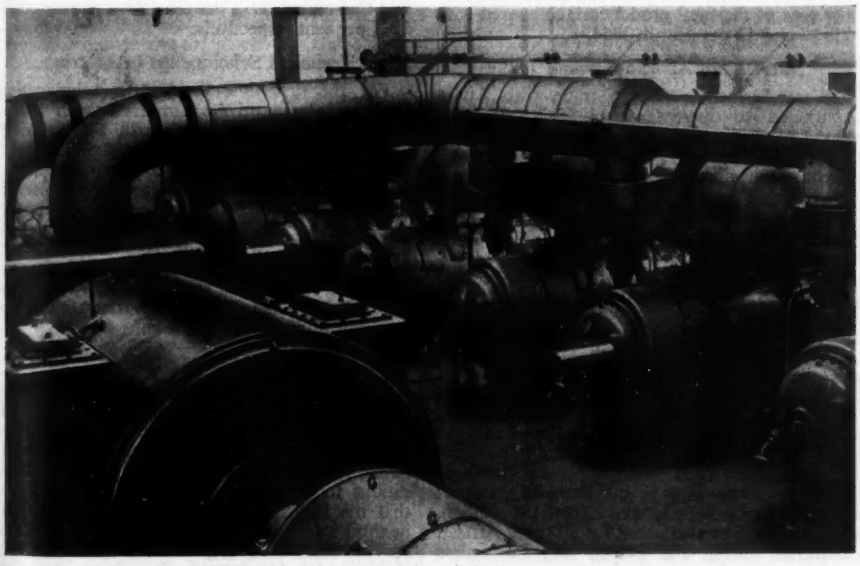
It was at the invitation of Alan Muntz and Co., Ltd., and S.I.G.M.A. that we were able to pay a visit to Cherbourg to inspect the Electricité de France power station and one of the French minesweepers, and observe free-piston gas generator engine sets operating under working conditions.

Basically the S.I.G.M.A. generating set consists of one or more GS-34 units supplying a gas turbine which drives an alternator directly or through reduction gearing. In the generator station at Cherbourg—seen in our illustration—the installation consists of eight GS-34 generators and one gas turbine, which has a maximum admission gas pressure of 4·48 hectopieze and a maximum admission temperature of 470 deg. Cent., and was built by the Compagnie Electro-Mécanique à Paris. The complete equipment has a weight of 124 tons, which is equivalent to 21 kg. per kilowatt. Each generator is rated at 750kW and the station develops 6000kW. Orders were placed in 1953 and the installation completed towards the end of 1955, and it is understood that within two weeks of completion the station was on full power, the only problems of note being the elimination of pipe vibration. Fuel consumption, based upon 800 hours of operation, was returned at 250 grammes per kilowatt-hour, but official trials, in which the units operated for six hours per day and included two stops, two starts per day and operation at full load and half load, gave a fuel consumption of 280 grammes per kilowatt-hour. Later it is intended to burn Bunker "C" fuel and the necessary equipment is being installed.

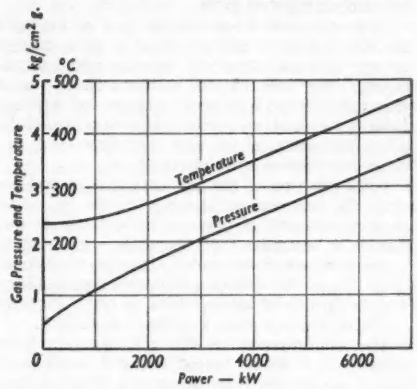
The turbine has nine stages of reaction blading and drives the Brown Boveri alternator, to which it is coupled through a clutch, at 3000 r.p.m. The generators are in groups of four, each group supplying gas to the turbine through a separate pipe, and between the engine exhaust chamber and the collector pipe is a by-pass valve, which discharges gas to atmosphere when the load on the turbine is reduced. This valve is controlled by the turbine governor, which also controls the setting of the fuel injection pump.

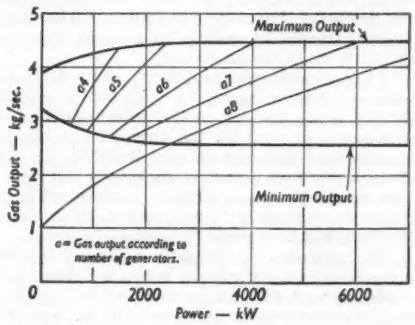
The graphs which we reproduce give the characteristics of the generating station; one plots temperature and pressure of the gas at the turbine inlet to a base of kilowatts and the other gives gas output in kilogrammes/second to a base of kilowatts for a varying number of generators, and also curves of maximum and minimum output. During the visit several aspects of the operation of the station were demonstrated. This included bringing the set into operation; the set was connected to the mains in a few minutes after starting the first generator and within six minutes was on full load. The next test demonstrated the advantage of employing a battery of independent generators, in that one was shut down in simulation of normal maintenance procedure. Service connections were broken and the cushion head, compressor piston, piston trunk, engine piston and other parts removed from one end of the generator. All the parts were reassembled and the generator was again in service within an hour. After a short period on full load a rapid reduction was made from 6000kW to 1000kW to demonstrate the turbine governor control. When the load was removed the turbine speed jumped to about 3200, but within a minute the speed had dropped back to the normal amount of 3000 r.p.m. The response of the set to load demands was then shown by rapidly raising the load back to 6000kW. Later the load was disconnected and the set operated under idling conditions before being shut down.

As mentioned earlier, the visit to the power station was followed by a visit to the Naval Dockyard to inspect the free-piston engine sets in one of the large number of French naval minesweepers fitted with this form of machinery. The propulsion machinery of the ship consists of two sets of gas turbines, each powered by one GS-34 free-piston gas generator, and each delivering 1000 h.p. at the propeller shaft. The gas turbine runs at 9000 r.p.m. and drives the propeller at 500 r.p.m. through reduction gearing. While on board starting of the gas generator was demonstrated, and also the ease of manœuvring resulting from the incorporation of an astern wheel in the gas turbine. This makes possible the gradual and continuous change of propeller speed from full ahead to full astern without affecting the gas generator, since the latter is not mechanically connected to the shafting. Controls consist of a three-way valve at the turbine, operated by a servo-motor at the control position, and an injection pump control. Before starting the generators the turbine control valve is set in the central position and the gas from the generator passes through both ahead and astern turbines, so that the torques produced are balanced and no power is transmitted to the propeller shafting. To move ahead or astern the controls are adjusted to close the inlet to astern or ahead turbines respectively.



Power station, showing some of the free-piston gas generators





Railway Electrification of the Saar Region

Following discussions lasting two years, agreement has been reached by the railway authorities of France, Luxembourg, the Saar, Germany and Belgium on the subject of electrifying the railways of the Saar and neighbouring regions (see also THE ENGINEER of May 4, page 463).

Investigation of the traffic problems of the iron and steel industries in the five countries has shown that the heavy international traffic which is being carried does not completely utilise the available capacity, and that

considerable increases in traffic volume could be handled by the railways even in their present state.

An examination of the various schemes for electrification or application of diesel power, projected or in progress, revealed, however, that one of the most important arteries of the network, the Moselle line from Koblenz to Ehrang and Thionville, and its offshoot from Ehrang to Bettembourg, Rodange, Mont St. Martin and Athus, had no scheme for the introduction of modern traction units.

It is over these lines that the bulk of the solid fuel from Aachen and the Ruhr is being carried to the iron industries of Lorraine and Luxembourg. The fact that the railways cross several frontiers and are split up among several different railway administrations has certainly provided the principal obstacle to any complete and co-ordinated scheme of modernisation.

Although one of the advantages of electrification, the increase in capacity of the line concerned, was not of primary importance in this particular instance, the committee appointed to study the matter concluded that the triangle of lines Mont St. Martin-Bettembourg-Ehrang-Thionville should be electrified, in order to make traffic operations more flexible and efficient.

The continuation of the electrification from Ehrang to Koblenz would make it possible to link up with the lines along the River Rhine, which are now being electrified. This matter is to be deferred until the German railway authorities feel that the step is economically justified within the general framework of their plan of modernisation.

For the international section mentioned, it has been decided to use industrial single-phase current at 25,000V, the advantages of which have been proved in the north-east of France. In this way good use will be made of the locomotives which will be able to run over the lines of the whole industrial part of Lorraine that is already electrified on the 25,000V system. The link-up with the Belgian 3000V d.c. system will be made at Luxembourg Station. The Saar itself is starting to electrify its principal lines on 25,000V industrial current.

The comparatively short length of the German section, which measures 42 miles out of a total of 116 miles, has led to the conclusion that it was not warranted for the German railways to acquire and maintain its own locomotives, and French and Luxembourg locomotives will therefore be used as far as Ehrang. The question of mileage payments for runs inside Germany and the Saar will be covered by special agreements.

The make-up of trains is governed by the existence of steam traction between Ehrang and Koblenz, and will not be modified by the proposed electrification. Current will be supplied from two substations, one in Luxembourg and the other at Thionville. Detailed technical studies now being made by the S.N.C.F. will determine whether a third substation at Ehrang is necessary.

Of the total capital cost of the fixed installations of about 600 million Belgian francs, about 31 per cent is the proportion required in Germany, 51 per cent in Luxembourg, 4 per cent in the Saar, and 14 per cent in France. Estimated annual saving in operating cost will be in the neighbourhood of 70,000,000 Belgian francs per year.

Thirty-three electric locomotives costing together 500 million Belgian francs will replace seventy steam locomotives now in service and save 60,000 tons of coal each year. It is considered possible that an appeal will be made to the High Authority of the European Iron and Steel Community to help finance the project.

French Electricity in 1955

Statistics recently published by the Electricité de France show that electricity consumption in France has doubled since 1946. Last year the generated total amounted to 49,540 million kWh, an increase of 9·1 per cent over 1954, and 103 per cent over the first post-war year (24,386 million kWh in 1946). Although the consumption of electricity was severely curtailed in the immediate post-war period, the progress made since 1950, practically the first year without restriction, is considered noteworthy, since an increase of 48 per cent has been achieved since then.

The 1955 output is divided into hydro-electric power at 25,600 million kWh, and thermal power at 23,950 million kWh. To these must be added imports of 720 million kWh, and against the total must be set exports of 790 million kWh and pumping power at 30,000,000 kWh. This compares with a hydro-electric production of 24,258 million kWh in 1954, coupled with 21,312 million kWh of thermal power, and imports at 575 million kWh, with exports at 832 million kWh and pumping at 40,000,000kWh.

During the year 1955 the installed hydro-electric capacity increased by only 0·5 per cent, and the production capacity in a mean year by 0·7 per cent. In spite of a rainfall 5 per cent below average (compared with 3 per cent below average in the preceding year), last year's actual hydro-electric output was increased by 5·3 per cent over 1954, chiefly through additional drawing down of the reservoirs.

An increase of 2640 million kWh, or 12·4 per cent, in thermal electric power was noted, as compared with 1954. Equipment with a total capacity of 543MW was installed.

Of the total hydro-electric power generated in France last year, about 19,770 million kWh came from power stations of the Electricité de France (18,765 million kWh in 1954). The difference of 5800 million kWh (5450 million kWh in 1954) was generated, mainly by the S.N.C.F. and the Compagnie Nationale du Rhône.

The contribution of Electricité de France to the thermal total amounted to 8750 million kWh (8000 million kWh in 1954), and that of others to 15,200 million kWh (13,350 million kWh in 1954). Chief among the latter are the coal mines (8800 million kWh) and the iron and steel industry (3600 million kWh).

Altogether, the contribution of Electricité de France amounted to 28,520 million kWh, or 57 per cent of the total, slightly less a percentage than in 1954, mainly because of the hydro-electric deficiency.

Total consumption was divided among the users as shown in the accompanying table :

Electricity Consumption in France

(Millions of kWh)

	1954	955
High tension :		
Coal mines	3,506	3,700
Iron and steel	3,687	4,200
Railways	2,250	2,400
Electro-chemistry, electro-metallurgy	7,028	7,850
Others	16,106	17,650
	32,577	35,800
Low tension :		
Domestic consumption	5,381	5,730
Street lighting	347	370
Other uses	1,890	2,000
	7,618	8,100

Transmission and transformation losses reached 5550 million kWh. Expressed in percentages, high and low-voltage consumption and losses, represented respectively 73, 16 and 11 per cent of the total production, compared with 71, 17 and 12 per cent in 1954.

Increase of African-German Trade

West Germany's foreign trade with Africa continued to increase in 1955. Last year DM.1470 million worth of goods were exported to Africa from the Federal Republic and West Berlin, as against DM.1330 million in the previous year. The comparable import figures were DM.1770 million and DM.1560 million.

As in other years, the Union of South Africa headed the list of West Germany's African trade partners, having bought DM.317 million worth of German goods in 1955 (1954, DM.256 million) and sold to West Germany DM.267 million (1954, DM.238 million).

Egypt ranked second, with DM.227 million as the figure for goods supplied by West Germany, and Liberia third with DM.176 million (of which, however, more than 90 per cent were accounted for by deliveries of ships to firms of other nationalities registered in Liberia). In 1954, more than DM.200 million worth of German exports went to Liberia, with deliveries of ships amounting to about DM.195 million. An increase was also noted for all other African countries, except the French and Portuguese areas.

As for German imports, the countries delivering the largest amounts of raw materials, after the Union of South Africa, were the Gold Coast (D.M.173 million), the Belgian Congo (DM.146 million), French Morocco (DM.144 million), and Egypt (DM.134 million).

Seventy-Fifth Congress of the French Association for the Advancement of Science

The Association Française pour l'Avancement des Sciences (A.F.A.S.) will hold its seventy-fifth congress from July 16 to 21, 1956, at Dijon. The meetings will take place under the chairmanship of Professor René Fabre, member of the Institute and of the Academy of Medicine, and doyen of the Pharmacological Faculty, who is president of the Association. A provisional programme has now been published. After the reception and opening ceremony of July 16, there will be daily scientific meetings from July 17th to 21st, in addition to which a number of excursions and visits are being organised. Further excursions will take place during the period July 22nd to 24th, after the congress has closed. In view of the fact that accommodation in the Cité Universitaire and elsewhere in the town is limited, those interested should apply at an early date to the Secretariat de l'A.F.A.S., 28, rue Serpente, Paris (6e).

The Telephone in Germany

The 4,000,000th telephone in the German Federal Republic was installed this year. A survey of telephone development in Germany shows that the first telephone exchange was opened with eight subscribers on January 12, 1881, in Berlin. The new means of verbal telecommunication, however, was none too enthusiastically received by the general public. The then Postmaster General, Heinrich von Stephan (originator of the World Postal Union), had to employ every conceivable publicity trick to popularise it. In May, 1889, the 10,000th telephone was installed in Berlin ; in 1921 there were 2,000,000 and in 1929 3,000,000 in operation in Germany. The first local dialling system, which was also the first in Europe, was inaugurated on July 10, 1908, in Hildesheim.

Women in Industry

The number of gainfully employed women in the Federal Republic is steadily increasing. According to the German Industrial Institute, 33·1 per cent, or almost one-third, of the working population in West Germany are women. Thus the Federal Republic holds third place, after Austria with 39·3 per cent, and France with 34·8 per cent. In Great Britain the comparable figure is 30·8 per cent, in Sweden 26·4 per cent, and in Italy 25·4 per cent. In the Netherlands and Belgium roughly one-quarter of the working population are women, while in Spain it is less than one-sixth. The corresponding figures for the U.S.A., Australia and Canada are 27·5 per cent, 23·4 per cent and 22·1 per cent respectively.

Technical Scholarships in Austria

For the first time in Austria, scholarships sponsored by a private firm have been established, the first two, each worth £430, having been awarded at the end of last year. They are intended to enable students to study chemistry, or some allied technical subjects, for a period of six years at an Austrian university. Instituted by Shell Austria A.G., the scholarships will continue to be awarded at the rate of two per annum, so that from 1960 onwards there will always be twelve Shell students ; they are to be selected by Shell in collaboration with the Austrian Ministry of Education.

Heinkel A.A. Missiles

It is announced that the Heinkel works is ready to begin constructing jet-propelled anti-aircraft missiles in West Germany. Ernst Heinkel, son of the well-known aircraft constructor, stressed that the technical conditions for such production are fulfilled and that the Heinkel works has developed its own method of constructing jet-propelled missiles. At present some 180 aircraft engineers are employed in the laboratories of the Heinkel works.

Current Trends in American Engineering Education

BY OUR AMERICAN EDITOR

The current industrial boom in the United States has brought about an unprecedented shortage of professional engineers and, as a result, there has been much discussion recently concerning ways and means to be adopted to overcome the present situation. A particularly interesting survey in this respect was conducted by the "Committee on Evaluation of Engineering Education" of the American Society for Engineering Education, and the present article is largely based upon the report which was published last year by the Society.

FOLLOWING a recommendation by the Engineers' Council for Professional Development, a "Committee on Evaluation of Engineering Education" was appointed in the United States in 1952. The Committee was given the task to recommend the pattern or patterns that engineering education should take in order to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century. The committee was asked particularly to clarify the curriculum content that differentiates engineering education from that in science on the one hand or in sub-professional technology on the other.

Development of the Engineering Faculty

In the opinion of the committee, distinguished faculties are far more important to the advancement of engineering education than details of curricula or magnificence of facilities. The university is a community of scholars and as such requires outstanding teachers to attract outstanding students. To improve and develop courses or curricula, to build up facilities—in short, to command respect as an educational institution—all require a faculty of competent teachers and scholars. It is felt that a thoroughly competent faculty can be acquired and maintained only if the college administration gives discriminating attention to the important problems of recruitment, selection, training, advancement and termination of appointment. Logically, however, the selection of competent staff members can be undertaken only after long-range curricular objectives have been formulated.

For a relatively young candidate for a faculty position, the strongest evidence usually available to measure a background of integrated fundamental knowledge and probable creative ability in teaching and research is an education which includes the doctor's degree. However, unless an academic environment is provided that will stimulate and retain men with an interest in creative work, mere insistence on degrees will not ensure high quality in a faculty. For experienced persons, evidence of the capacity of the individual for creative teaching and research may be gauged by other criteria, and the formal educational background is of less significance. In line with the considerably greater accent placed in the United States upon higher degrees, the committee believes that young engineering teachers who hold only the bachelor's degree should be employed only in a temporary position that presupposes a continuation of their education. Lack of such progress should be sufficient reason for terminating their appointments. Appropriate professional experience in industry, government, or private practice, is considered to be important in a well-balanced faculty. This experience should be considered in the selection and advancement of individuals, but it need not be a requirement for faculty members with a special educational background or with demonstrated creative ability in research or teaching. Every teacher, regardless of his background, should strive to become a recognised expert in his field. There is no substitute for knowledge of subject matter far beyond the limitations of that to be taught. However, it is recognised that mastery of subject matter alone will not guarantee good teaching and that neither industrial experience nor advanced degrees are adequate criteria in themselves. The minimum essentials for good teaching are the mastery of subject matter and the capacity of the teacher to draw students into active participation in the learning process. Strong individuality is often characteristic of distinguished teachers, but the capacity to co-operate with colleagues in carrying out the institutional programme as a whole is, nevertheless, of great importance.

The report states that the effective recruitment and retention of a qualified faculty will require, in colleges of engineering, the establishment of a salary scale comparable to the income earned by outstanding practicing professional engineers. Accepted practices in establishing adequate faculty salary scales in the professions of medicine and law indicate that competitive situations must be met if professional education is not to stagnate. It should be recognised that, in contrast with the situation in many academic fields, industry is inherently attractive to many of the best engineering minds. In the United States there is a particularly large salary differential between teaching and industrial employment, and unless this salary differential is minimised, a sufficient number of superior engineers will not be attracted to or retained in the teaching field, to the detriment of the whole profession, of industry, and of the country.

In engineering teaching, continual contact with the forefront of engineering and scientific progress is essential. Leadership in scientific and engineering progress has frequently stemmed from university research activities. In the opinion of the committee the engineering teacher carries a responsibility to contribute to the advancement of knowledge through engineering research. The university must provide the opportunity to realise this objective in terms of time, facilities and assistance. It is only when teachers of professional subjects are recognised as experts that they have an opportunity to do consulting work. Hence, the ability to engage in such consultation is not considered to be a major factor in the recruitment of young teachers. Consulting practice should be considered as a means of developing and further strengthening an engineering faculty. Close association with engineering work or research in industry should stimulate the teacher and improve his teaching. Consulting is also a source of ideas for research. The limit upon the useful extent of this activity has not been determined. However, the belief is widely accepted that an average of one day per week of the individual teacher's time devoted to consulting activity of a high professional character will reflect to the overall advantage of the institution.

Summing up, the committee believes that the evaluation of a potential faculty member should be objective and should place emphasis upon: (1) the effectiveness of the individual's teaching based upon his knowledge of subject matter, intellectual capacity, judgment, professional and personal stature, and qualities of personal leadership as shown in his ability to inspire students. (2) His productivity in research and other creative areas, including new methods of presentation of subject matter. (3) His professional development as evidenced by progress in early years toward advanced degrees, by accomplishments in engineering practice, or by attainments and recognition as a scholar in his field. (4) His significant publications. (5) Evidence of his professional interest as shown by his activity in professional societies and in governmental and community affairs, and by his registration as a professional engineer.* (6) The nature and responsibility of his consulting services to other areas of the university and to outside organisations.

Objectives of Engineering Education

The Committee feels that the ultimate goal of engineering education is the development of able and responsible men fully competent to practise on a professional plane, especially those who will eventually lead the profession to new heights of accomplishment through creative practice or research. The student, not the curriculum, is the primary concern, yet the curriculum has an important influence on education. Before considering curricular components, the instructional goals toward which they are directed should be examined. The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles, on his own initiative, with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology and to continue to grow intellectually in both professional and cultural areas throughout life.

In professional engineering practice the "new situation" often involves social and economic as well as technical elements, and these are not entirely separable. Thus the end result is not merely the numerical solution of a technical problem, but is rather a decision based on a value judgment to which the quantitative technical result contributes one important element. In fact, the significant problems involving engineering seldom occur in well-defined form. Hence the initial stage of thinking is often an intuitive groping to identify specific component problems. Their solution, in turn, requires the application of thoroughly understood fundamental principles and well-ordered analytical thinking in defining the problem, planning its simplification without losing its essential nature, conceiving a method of attack, carrying the study through to a successful conclusion, and checking the results at each stage. This technical solution is then available to guide the engineer when he considers the broader social and economic aspects of the problem. His final decision will be influenced by the extent to which his perspective and judgment transcend purely technical matters.

It is emphasised that engineering educators must never lose sight of the broad issues with which large engineering problems are always associated, although the ability to deal effectively with such broad issues comes only after college. The importance of keeping such economic and social ideas before students by example can hardly be over-emphasised. Such concepts should be encompassed even though the main effort at the undergraduate level is largely restricted to developing the student's ability to master the scientific and technical aspects of engineering education.

It is clearly recognised that many engineers progress into managerial and top executive positions in industry and government. For such individuals the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build. This foundation may be built more solidly in humanistic and social courses than in highly applied studies in management. Education for the profession of engineering does not stop with the acquisition of a degree; it must continue throughout life. Hence, one of the significant instructional goals of engineering education is to motivate the student to learn on his own initiative.

The basic sciences which make up the foundation of engineering curricula are usually considered to include mathematics, physics and chemistry. A casual perusal of current professional journals is sufficient to show that all branches of engineering are continually becoming more dependent upon mathematics of an increasingly high level. In fact, engineering

* Registration as a "Professional Engineer" in the U.S.A. is more or less equivalent to obtaining membership or associate membership of one of the senior engineering institutions in the United Kingdom.

judgment is more and more often guided by mathematical analysis, and such analysis is rapidly expanding the demands it places upon advanced areas of mathematics. At the undergraduate level competence in the theory and use of simple, ordinary differential equations and their application to the solution of physical problems lies close to the boundary of minimum acceptability of mathematics in any satisfactory engineering curriculum. For students who will be chiefly interested in research, development or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary. A minimum level of performance in mathematics should be established, whether it be obtained in required mathematics courses or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the student's knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making affective use of such mathematical proficiency and should be taught by staff members who have this proficiency.

Too often, physics as presently taught to engineers in America barely touches upon the many new physical concepts which have been developed during the past generation and which to-day strongly influence engineering practice. Modern physics, including an introduction to nuclear or solid state physics, should be a part of undergraduate engineering curricula. As a contribution to making this presentation to engineers as effective as possible in a limited time, it is believed that the basic course in physics needs a new orientation. The duplication between classical physics and the engineering sciences of mechanics, thermodynamics and electricity can be largely removed if the objective of the introductory physics course is redirected to place much greater emphasis upon submicroscopic phenomena and the conservation principles, with virtual elimination of semi-engineering examples. An introductory course in physics that attempts to be an ancillary subject for engineering mechanics, thermodynamics and electricity appears to serve less and less purpose. When engineering colleges request physics departments to present an introductory course in atomic physics for large numbers of engineers it seems evident that the introductory physics course will then have to be remodelled to provide the strongest possible background for this new objective.

In the opinion of the Committee, chemistry should include topics in the inorganic, organic, and physical branches presented in a condensed and general form. The initial study must prepare engineers to enter advanced courses in chemistry and in its applications to such fields as properties of materials, metallurgy, fuels and combustion, corrosion, and industrial chemical processes. Hence such subjects as rates and kinetics of chemical change, chemical equilibria, phase diagrams, solutions, electrochemistry, and colloids should be included. Careful co-ordination should also be effected between modern physics and chemistry. For studies beyond the usual first year chemistry course it is felt that physical chemistry deserves the main emphasis.

An engineering science has been defined in the report as a subject that involves largely the study of basic scientific principles as related to, and as related through, engineering problems and situations. Engineering science stems from two basic areas : mechanical phenomena of solids, liquids and gases ; and electrical phenomena. A common practice is to subdivide these into the following six engineering sciences : (1) mechanics of solids (statics, dynamics and strength of materials), (2) fluid mechanics, (3) thermodynamics, (4) transfer and rate mechanisms (heat, mass and momentum transfer), (5) electrical theory (fields, circuits and electronics), (6) nature and properties of materials (relating particle and aggregate structure to properties).

Few existing American curricula contain all six engineering sciences, despite wide agreement as to their basic desirability. It is evident that the engineer needs background in all of the six fields listed. Only after careful consideration and determination that the fundamental concepts are substantially covered in other studies at an equivalent mathematical level, should one of these engineering sciences be omitted from a curriculum. Alternately, there may be some curricula or engineering syllabuses for which sciences other than those listed must be chosen ; for example, a life science or an earth science.

Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, development and engineering research is the most distinctive aspect of engineering curricula. Such education intrinsically stems from the case method of approach, rather than from an orderly exploration of a given subject matter field. It is felt that some experience in this " design " function should be carried in an integrated manner through each semester of the last two years and may be begun earlier if practicable.

Among the various mechanisms for implementing the case method are theses, research projects, group operations, competition between groups, the use of realistic or unsolved problems, examinations on unfamiliar subject matter, and the synthesising of a new device rather than the analysis of an old one. These case studies go far beyond and are quite different from routine repetitive aspects of practical design, the use of handbooks, or the description of structures, equipment, or machines, including their construction, operation, and maintenance. Such engineering art is learned more effectively from field experience than from college study. The capacity to design includes more than mere technical competence. It involves a willingness to attack a situation never seen or studied before and for which data are often incomplete ; it also includes an acceptance of full responsibility for solving the problem on a professional basis.

This portion of many engineering curricula demands close scrutiny and continuing active change. The major department sequences in many instances are dull and uninspiring, utilising practices long outdated. These are areas in which newly developed concepts, analytical techniques and measurements should be brought to bear. They should be taught by men who are making active contributions to engineering progress. For example, courses in internal combustion engines are often largely descriptive in nature, and hence are considered to be essentially sub-professional. They can be vital experiences in which the principles and advanced analytical techniques of mechanics of solids and fluids, thermodynamics, and heat transfer are used effectively ; the nature of combustion, friction and materials are considered, and creative thought and imagination are brought to bear in producing an integrated system. To do this is a difficult and challenging job, but a very necessary one. These observations apply with equal force to such subjects as highway engineering, electrical machinery, chemical processing, extractive metallurgy, &c. It is important again to stress the necessity of utilising fully in such studies the basic and engineering science training at the appropriate level.

The laboratory is the means of teaching the experimental method. It should give the student the opportunity to observe phenomena and seek explanations, to test theories and note contradictions, to devise experiments which will yield essential data, and to interpret results. Therefore, laboratories should be used where and only where these aims are being sought. The value of a set number of stereotyped experiments is questionable. The development of a smaller number of appropriate experimental problems by the students themselves under effective guidance will have much greater educational value. The art of measurement—including analysis of accuracy, precision and errors—and the appreciation of the degree of accuracy economically justified, together with some understanding of statistical methods, are essential elements of laboratory experience. Laboratory reports, when restricted to a few per semester present a major opportunity to develop skill in the written presentation of engineering information. Stereotyped reports are felt to be valueless in teaching the art of communication.

The goals of engineering education already outlined require for their achievement adequate attention to subjects in the humanistic and social fields. In addition to technical knowledge and skill, the professional engineer needs to have some acquaintance with the subject matter of fields other than his own, with their influence upon the lives of men, and with their relationships to his own profession. To the attainment of these objectives both the technological and the humanistic divisions of the curriculum should contribute as integral parts of one total programme. It is a mistake to look upon technology alone as the productive component of the student's development and on the humanities as providing only the liberalising elements in his pattern of growth. On the contrary, all of his courses of study, whatever their specific objectives in knowledge or skill, should be so designed and taught as to contribute toward the student's development as a truly educated man whose convictions, understandings, manner and speech are intimately related components in the fibre of his life.

At this point, the Committee made some pertinent comments about English, which is both utilitarian and humanistic. Facility in expression, written and oral, is a professional necessity and an overall personal asset. Knowledge of literature and the ability to read with sympathetic understanding are parts of a liberal education. English, therefore, has one root planted in the humanistic portion of the curriculum, another in the technological. For developing skill in English usage sufficient for the professional engineer, sole dependence upon specified courses is not enough. Adequate motivation is essential ; it can be attained only by active efforts on the part of all teachers to point out the economic and cultural rewards which will accrue to engineers who develop skill in the art of verbal communication. This requires personal counselling and sympathetic understanding of the student's pre-college cultural background, as well as insistence on the highest attainable standards of performance in written and oral work in the engineering courses.

Evolution of Engineering Curricula

The great changes in physics and chemistry over the past thirty years and the equally great advances in engineering practice, do not seem to have produced an equivalent counterpart in a reorganisation of American engineering curricula. A group of industrial advisers to the Committee has pointed out that the problems in production and manufacturing are now demanding greater and greater scientific background for engineers. As one example, emphasis was placed upon " automation " as a current problem of the machine designer. The need for such instruction is critical in certain industries, and several of these offer such courses to their personnel. If this is generally true, engineering education may be a decade late in giving emphasis to electronics in the curriculum of mechanical engineering or in teaching applied electronics as a part of machine design.

It is relatively easy to look backward and recognise changes ; it is more difficult to visualise what lies ahead. After facing many questions regarding the future of engineering practice one is likely to conclude that the teaching of practice, as it exists to-day, will always be of limited use because the graduate is certain to find practice changing from year to year. And, as a matter of fact, the engineering art taught in colleges will normally reflect practice that is already obsolete in part, since the teacher's knowledge of practice becomes rapidly outdated. But fortunately, some things do not change. Reactions, stresses, and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics, and heat flow will be as important to the next generation of engineers as to the present one. Solids, fluids, and gases will continue to be handled and their dynamics and chemical behaviour will have to be understood. The special properties of materials as dependent upon their internal structure will be even more important to engineers a generation hence than they are to-day. These studies encompass the solid, unshifting foundation of engineering science

upon which the engineering curriculum can be built with assurance and conviction.

The problem that faced the Committee on Evaluation of Engineering Education soon after its organisation was to think through the implications of the steadily increasing importance of the engineering sciences upon curriculum design and upon faculty, students and employer relations. The questions to be answered were of the following nature. Would faculties believe that much stronger emphasis upon the engineering sciences and the basic sciences will produce only research men ? Would the employer be pleased with graduates of such programmes or would he prefer men able to earn their salary immediately upon graduation without special job training ? Could students undertake a more scientific programme without excessive failures ? Not knowing the answer to these questions, the Committee suggested in its Preliminary Report the concept of bifurcation as a possible means of transition from the present curricula, which are largely of the general professional category, to the strong scientifically oriented curricula that it visualised as being required for an unknown, but in no sense negligible, percentage of future graduates. As defined in the Preliminary Report, the scientifically oriented curriculum included increased emphasis upon mathematics and physical science, the engineering sciences as previously described, and a two-year sequence of courses in engineering analysis, design or the study of engineering systems.

The discussions of the Preliminary Report which were forwarded to the Committee by the colleges of engineering established a reasonably clear viewpoint. This concensus of engineering faculties consisted of three parts : (1) a strong support for higher standards of accreditation for engineering education, but not for designation of especially meritorious curricula ; (2) a nearly universal institutional reaction that engineering curricula should not be subdivided into two functional stems, but a recognition of the usefulness of functional variation at the top ; and (3) a growing desire for a deepening and broadening of basic science content throughout all engineering curricula.

After receiving this expression of attitudes from the engineering institutions the Committee determined to learn something of the viewpoint of employers. At a meeting in Atlanta, Georgia, in February, 1954, seven of the largest American employers of engineers were invited to advise the Committee. These organisations employ engineers in all functions from research to sales and construction. In fact, most of the organisations represented employ only a small fraction of their engineers in research, development and design. On the average less than 25 per cent of their engineers work in these fields. One company has most of its engineers employed in operation and another in manufacturing. A third has one of the largest construction organisations in the country. Several employ nearly one-half of their engineers in sales. Nevertheless, the industrial representatives who were present concluded that they would prefer nearly all of their engineers to be trained in scientifically oriented curricula.

The industrialists emphasised that their sales, manufacturing, operation and maintenance engineers need strong scientific backgrounds, just as much as do their research and development engineers and their designers. They were unwilling to sacrifice courses in engineering sciences to provide time for the study of technology or administration at the pre-baccalaureate level, since they believe that these can be obtained under company sponsorship when needed. Initially the industrial advisers to the Committee represented only large employers. Therefore the Committee requested one of the companies to make a survey of a number of smaller organisations at the operating and manufacturing level. The returns indicated no criticism of the technical competence of engineers, but raised questions concerning (1) the adequacy of their background in basic science, engineering science, and humanistic fields ; and (2) concerning their capacity for effective communication. This reaction with regard to the inadequacy of basic science and cultural background was essentially unanimous.

Post-Graduate Study in Engineering

The growth of post-graduate study in engineering in the United States during the past two or three decades has been remarkable. Both statistically and in the minds of those concerned with engineering education, graduate study has become an element of such major importance that it necessitates serious attention in any evaluation of engineering education.

The need for post-baccalaureate study by those who are to advance to-day's highly complex technology is generally recognised. The four-year undergraduate programme, even with increased scientific emphasis, simply cannot provide the depth and breadth of scientific foundation and the background for creative thinking in design which are needed. The need for graduate education varies with the rate of advance in the use of science characterising various fields of engineering ; it is greatest in those fields in which this rate is most rapid or to which science can contribute most directly. American industry places a substantial value upon graduate education, as indicated by recruiting efforts, salaries and advancement to positions of high degrees of responsibility. Furthermore, engineering education must be based more and more on a profound knowledge of the basic sciences and so will require that an increasing proportion of its teachers will have the benefit of advanced education. It is obvious, therefore, that educational institutions with adequate resources to support good post-graduate work in engineering have not only an opportunity but also an obligation to attract and develop as many well-qualified graduate students as possible. Those educational institutions which operate solely on the undergraduate level have also an obligation to participate by preparing and encouraging their students to take post-graduate work elsewhere. Many small colleges have made impressive records in furthering post-graduate education in this way. Even institutions having well-developed post-graduate programmes should encourage their better students to enrol in other similarly qualified institutions for post-graduate study because of the educational advantages to the student of new scholastic environments and different personalities among their instructors.

It is traditional for institutions of higher learning to serve two ends : disseminating and extending learning—that is, education and research. It is common to distinguish three separate yet closely related activities : undergraduate education, post-graduate education, and fundamental research. When these are maintained in adequate balance and properly correlated, each can enormously strengthen the other two. One kind of correlation that is very effective is attained by having faculty members who wish to engage in all three activities.

Although one conception of the purpose of post-graduate study is that of increased specialisation in a narrow field, the Committee feels that a broader conception, developed as discussed below, is more significant. For example, the topics in organic and physical chemistry or in solid-state and nuclear physics, which seem so essential to one "specialised" post-graduate programme in engineering, will be almost exactly duplicated in many others. Graduate study in engineering thus has a broad common base in science and mathematics. Such concentration as may be desirable, for example, on a thesis, should be undertaken with the objective of developing breadth of understanding and capacity to solve difficult problems. Naturally the student who studies intensively in one particular field possesses a ready skill in this special area which may have immediate utility. Such facility, however, has only a temporary value without the overall intellectual growth through which the individual can master new techniques in any of numerous fields. The acquisition of techniques is therefore incidental in post-graduate educational experience, the deepening of insight and understanding, and the development of the stronger intellectual and scientific foundations that are required for real mastery of the field involved.

Hence the objectives of post-graduate study in engineering are the development of (1) a more general and fundamental understanding, not only of the sciences specifically underlying a particular field, but also of those underlying related fields ; (2) more general and more powerful methods of analysis ; (3) capacity to read with understanding the advanced work, classic and contemporary, through which the field is advancing ; and (4) courage, imagination and technical capacity to make new advances and to know the methods as well as the failures and successes involved in such advances. A recognised objective which is being implemented at a few institutions is that of continuance of general education outside the fields of engineering and science at a serious and mature level. This is particularly important for those who expect to become engineering teachers. The growing broad responsibilites of all engineers further justify increasing attention to this objective. Culture can, of course, be acquired by penetrating self-study in a variety of fields or assimilated by close association with scholars.

In the last decade the amount of sponsored research carried on by American engineering colleges has grown enormously. Sponsored research programmes properly conceived and carried out can be great assets to both post-graduate and undergraduate schools. They provide a means of professional development for staff members. However, only when tied closely into the post-graduate school programme will they provide opportunity for students to deal with real and challenging problems as a part of their education. A criterion of acceptability for each project is that competent faculty members actively desire to work on it. However, growth in the size of the projects may so consume the time and energies of the staff that their contribution to education diminishes, particularly if the work becomes more routine and less challenging. The college administration is responsible for the establishment and control of such programmes, for retaining proper balance between the sponsored research commitments and the other parts of the educational programme of the institution, and for taking whatever steps are necessary to ensure that services performed on projects provide opportunity for professional growth for the faculty and the graduate students.

Conclusions

The Committee has been concerned with what it believes to be reasonable, attainable objectives, rather than with Utopian goals on the one hand or minimum standards for accreditation of undergraduate curricula on the other. Nevertheless, responses to the earlier reports evidenced a wide desire to raise hitherto accepted minimum standards, and it is anticipated that the report will assist the Engineers' Council for Professional Development.

In closing the report the Committee re-emphasised that it believes the spirit of its recommendation in advocating scientifically oriented undergraduate curricula to receive more attention than mere observation of proposed fractions of time devoted to particular areas. It gave a great deal of thought to the possibility of prescribing the level of attainment in each of the areas of importance in engineering education, but it was unable, except possibly in mathematics, to make a quantitative specification which would take into account the inherently dynamic nature of the basic sciences and more especially that of the engineering sciences. College faculties must perform this work year by year.

The task initially undertaken by this Committee is not finished nor can it ever be finished. The problem of the evaluation of engineering education should always be in the consciousness of the members of faculties of engineering colleges. Each teacher must consider this task a vital personal one and approach it with intellectual vigour and full consideration for the needs of an expanding economy, requiring engineers with vision, creative ability and sound training of truly fundamental nature. Since these desired qualities cannot be achieved for all students in an identical manner, elective study is recommended. The choice of electives at the undergraduate level contributes to the development of a stronger humanistic and social background for some engineers and a stronger scientific background for others with a resultant overall strengthening of the profession of engineering.

Personal and Business

Appointments

MR. L. R. P. PUGH has been appointed a director of Guest Keen Iron and Steel Company, Ltd.

MR. W. M. YORK has been appointed commercial director of E. K. Cole, Ltd.

MR. L. H. MCROBERT has been appointed to the North Eastern Area Board of the British Transport Commission.

MR. R. DAVIES has been appointed London and Southern Area representative for Modern Machine Tools, Ltd., Broadgate House, Coventry.

MAJOR B. BRUCE KENNEDY, managing director of James Kennedy and Co., Ltd., has been elected chairman of the Timber Development Association.

THE BRITISH BROADCASTING CORPORATION states that Sir Harold Bishop, the director of technical services, will be known in future as the director of engineering.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2, has announced the appointment of Mr. Clifford Smith, A.M.I.E.E., as manager of the marine department.

REMINGTON RAND, Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1, states that Mr. John Winton has been appointed assistant to the general sales manager, office equipment.

THE ELECTRICAL RESEARCH ASSOCIATION says that, following the death of Dr. S. Whitehead, Mr. L. Gosland and Mr. H. M. Lacey have become joint acting directors until such time as a new appointment to the office of director is made.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, has announced the appointment of Mr. E. J. Scotcher as assistant superintendent, control department. Mr. W. E. Gee has been appointed assistant traffic manager (export).

THE BRITISH TRANSPORT COMMISSION announces the appointment of Mr. S. A. Finnis as chief docks manager, Southampton, and Plymouth. He will succeed Mr. R. P. Biddle, who is to retire on September 30th. Mr. Biddle has been docks and marine manager at Southampton since 1936.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., announces the appointment of Mr. D. Allsop as manager of the construction department of The British Thomson-Houston Company, Ltd. He succeeds Mr. A. S. Kettle, who has relinquished the position in order to devote all his time to other duties with the company.

Business Announcements

Mechanics has changed its address to 19-20, Noel Street, London, W.1.

PERMALI, Ltd., states that Permali Inc. has opened a new factory at Mount Pleasant, Pittsburgh, U.S.A.

RADIOVISOR PARENT, Ltd., has moved to its new factory at Stanhope Works, High Path, London, S.W.19.

IRAN OIL PARTICIPANTS, Ltd., has changed its address to 3, Finsbury Square, London, E.C.2 (telephone, Monarch 6030).

FIRTH BROWN TOOLS, Ltd., has moved its Manchester office to Speedicut House, Royle Street, Fallowfield, Manchester, 14.

THE MARLEY TILE COMPANY, Ltd., has acquired the whole of the capital of Wallington Weston and Co., Ltd., Frome, Somerset.

ALFORD AND ALDER (ENGINEERS), Ltd., Hemel Hempstead, Herts, states that it has merged with the Newton group of companies.

MR. MILES BEEVOR, deputy chairman and joint managing director of The Brush Group, Ltd., is engaged on a tour of Canada.

VICKERS, Ltd., states that it has acquired a controlling interest in Canadian Vickers, whose works and shipyards are at Montreal.

JABROC, Ltd., and HYDULIGNUM-JABROC (TOOLS), Ltd., Mill Lane, Waddon, Surrey, state that their telephone number is now Croydon 7187.

THE EXPORT CREDITS GUARANTEE DEPARTMENT has moved its Bradford office to Britannia House, Bridge Street, Bradford, 1 (telephone, Bradford 25147).

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Manchester, has acquired a site at Tyntesfield, Sale, Cheshire, for the erection of a hostel for its apprentices.

MARTIN, BLACK AND CO. (WIRE ROPES), Ltd., has opened a N.E. area office at Guildhall Chambers, 13, Sandhill, Quayside, Newcastle upon Tyne (telephone, Newcastle 2-1282).

JOHN LYSAGHT'S BRISTOL WORKS, Ltd., states that its London constructional department has been moved to Swan House, 34-35, Queen Street, E.C.4 (telephone, City 5070).

RCA GREAT BRITAIN, Ltd., is the new name of the company hitherto known as RCA Photophone, Ltd. Its address is Lincoln Way, Sunbury-on-Thames, Middlesex (telephone, Sunbury-on-Thames 3101).

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has moved its Swansea sub-office to 166, St. Helen's Road, Swansea. The Edinburgh sub-office has been moved to 61A, Queen Street, Edinburgh, 2.

COMPOFLEX COMPANY, Ltd., states that its "Southern Flexibles Centre," and its head office and sales staff, are moving on July 2nd to 23–25, Northumberland Avenue, London, W.C.2 (telephone, Trafalgar 7800).

MONSANTO CHEMICALS, Ltd., is now moving its London headquarters to Monsanto House, 10-18, Victoria Street, S.W.1 (telephone, Abbey 5678; telegrams, "Monsanto London Telex"). The move will be completed by June 25th.

THE GENERAL ELECTRIC COMPANY, Ltd., and THE BRITISH TABULATING MACHINE COMPANY, Ltd., announce that they have entered into arrangements for collaboration in the design of computers and like equipment to cover the field in which such devices can be employed, and particularly the sphere of office machinery and automation. It is intended to form a new company, the capital of which will be held equally by the parent companies. The financial, production and distributing structure of the parent companies will not be affected by this arrangement.

Contracts

HUMPHREYS AND GLASGOW, Ltd., Humglas House, Carlisle Place, London, S.W.1, has received contracts from the East Midlands Gas Board to build catalytic oil gasification plant utilising the Onia-Gegi regenerative process. Two units are to be erected at Meadow Hall gasworks, Sheffield, and two at the Northampton gasworks. Humphreys and Glasgow, Ltd., has also received from the Osaka Gas Company, Japan, a contract for two carburetted water gas plants for the Kyoto works.

DORMAN LONG (BRIDGE AND ENGINEERING), Ltd., has obtained the contract from the Lancashire County Council for the construction of Higher Walton bridge, which carries the new Preston by-pass motorway, over the River Darwen and the main Preston to Blackburn Road A.675, about 3 miles south-east of Preston. The value of the contract is £193,690. The proposed motorway has dual carriageways, 36ft wide, two 5ft footpaths, and a 12ft central reservation, making the total width between parapets about 94ft. The bridge consists of eight parallel plate girders, 6ft deep and 474ft long, continuous over six spans. The plate girders are of welded steel construction throughout and support a reinforced concrete deck. The northbound and southbound carriageways are independent of each other. The total weight of steel in the bridge is 670 tons and will be manufactured at the company's works on Tees-side.

DORMAN LONG (BRIDGE AND ENGINEERING), Ltd., has been awarded the contract from the Iraq Government Development Board for the building of the Nasiriyah Highway Bridge over the River Euphrates. The value of the contract is £638,895 and the consulting engineers are Messrs. Rendel, Palmer and Tritton. The structure will be a three-span cantilever bridge of steel plate girder construction on caisson foundations. The overall width of the deck will be 36ft, the central span of 250ft being flanked on either side by a span of 170ft, and at both ends of the bridge there will be steel and concrete approach ramps and viaducts with piled foundations. The whole of the structure will require approximately 1400 tons of steel, which will be manufactured at the company's works on Tees-side. This contract follows another road bridge over the Euphrates at Hindiya, built by Dorman Long and opened by the Prime Minister of Iraq in April last.

Miscellanea

MR. W. M. MULLINS.—We have learned with regret of the death of Mr. W. M. Mullins, which occurred on May 19th. Mr. Mullins had been technical director of Nu-Way Heating Plants, Ltd., Droitwich, for the past twenty-one years.

EXHIBITION OF PHOTOGRAPHY.—The annual exhibition of the Institute of British Photographers was opened in London last week and will continue until Saturday, June 9th. The exhibition covers the whole range of photography in the service of science and industry.

KRUPP-ARDELT G.M.B.H.—On page 538 of our May 18th issue, we published a description of a mobile level-luffing crane made by Krupp-Ardelt G.m.b.H., Wilhelmshaven, and shown at the recent German Industries Fair at Hanover. We should point out that J. M. J. Maus, Ltd., 35, New Broad Street, London, E.C.2, is the sole agent for Krupp-Ardelt G.m.b.H. in the United Kingdom.

AUTOMATIC PUMPING CONTROL AT THE CHEW VALLEY SCHEME.—In our article with the above title, published in THE ENGINEER of May 11th, we stated that the capacity of the service reservior at Stowey was ¾ m.g.; in fact, the reservoir is of ¼ m.g. capacity. The Stowey pumping service is controlled in seven 1 m.g.d. stages, and there are seven "stage receivers" on the main control panel to select the required rate of pumping.

FACTORY EXTENSION.—A new extension to the head office and works of Black and Decker, Ltd., at Harmondsworth, just completed, increases the original factory floor area of 80,000 square feet by some 40,000 square feet. For it the existing building was extended by new structures on two adjacent sides. Besides extending the production space, the firm has made additions to the main administration block, which runs along one side of the production area, and at the west side of the factory a new polishing shop and a new canteen have been erected adjoining the main structure.

GUIDE TO SCREW THREAD FORMS.—The multiplicity of screw thread forms in use in various parts of the world is often a source of difficulty to designers, particularly when it is required to trace an unfamiliar form. For this reason a new publication of W. H. A. Robertson and Co., Ltd., Lynton Works, Bedford, which is entitled "A Guide to Screw Thread Forms of the World," will prove a valuable addition to the works of reference used by draughtsmen, designers and all manufacturing engineers. No less than sixty screw thread forms in common use throughout the world are illustrated with their leading data.

BRITISH CHEMICAL PLANT MANUFACTURERS ASSOCIATION.—The report for the year 1955 issued by the British Chemical Plant Manufacturers Association records the membership increased from 209 to 215 during the year. With regard to research, the report states that a Research Committee is to study research being conducted elsewhere and that an information exchange service is to be set up for the dissemination of existing chemical engineering knowledge. Questions relating to standardisation, raw materials, machinery imports, are discussed and a tabular statement illustrates the trend in exports of various forms of chemical plant.

PETROCHEMICAL PLANT.—The Shell Petroleum Company, Ltd., announces that the Partington plant of Petrochemicals, Ltd., is to be extended to meet the increased demand for ethylene and propylene derivatives. Part of the new facilities will produce about 25,000 tons per annum of ethylene oxide by the direct catalytic oxidation of ethylene and when completed by mid-1958, the existing ethylene oxide plant will be used to expand propylene oxide production. A plant for the conversion of ethylene oxide to ethanolamines was completed at the beginning of the year and additional production capacity for glycol ethers, polyglycols and non-ionic surface active agents is under construction.

CORROSION AT BIMETALLIC CONTACTS.—A booklet entitled "Corrosion and its Prevention at Bimetallic Contacts" has been published on behalf of the Corrosion and Electrodeposition Committee of the Inter-Service Metallurgical Research Council (Admiralty and Ministry of Supply). It is designed to provide up-to-date and reliable information on the subject to all who are concerned with metallic corrosion. The text provides general information about the conditions in which bimetallic contacts are most likely to lead to troublesome corrosion and also about the means of mitigating such effects. In the table which follows a system of symbols is used to indicate the relative effects on the corrosion of a range of metals when brought into mutual contact and bridged by water containing an electrolyte. The table is arranged in two main groups of metals, the first in sequence approximately similar to the "Schedule of Potentials" included in many documents. The second group comprises chromium-stainless steel, titanium and aluminium, which metals develop highly protective oxide films and behave as relatively noble metals under conditions favourable to the maintenance of such films, but are in some cases less resistant in conditions in which breakdown of the films is possible. It is these metals in particular that cause difficulty in attempting to predict the behaviour of bimetallic contacts from a schedule of potentials. The book is published by H.M. Stationery Office, price 1s. 6d.

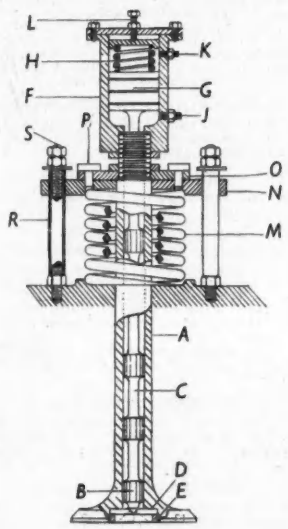
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application: the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

748,589. May 14, 1954.—Fuel Injection Systems, Ronald David Jones, 45, Lealholm Road, South Gosforth, Newcastle on Tyne, 7.

The invention relates to a mushroom valve which can be utilised either for air induction or exhaust in a diesel engine, combined with a fuel injection valve of the needle type. Referring to the drawing, the stem of a mushroom valve *A* is bored an easy fit to accommodate bearing strips *B* on a fuel injection valve stem *C*, and the valve *A* is machined at the mushroom end to receive fuel spray cap *D*, which provides a seating for the fuel injection valve. The cap is provided with one or more spraying orifices and is secured in position by a screwed ring *E*. Bearing strips *B* are fluted to form fuel passages. The end of stem *A* is threaded to accept a member *F* which houses

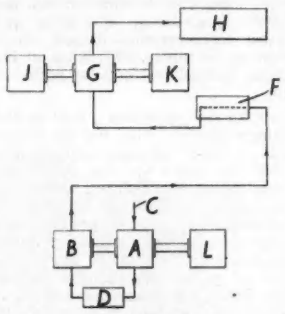


No. 748,589

actuating piston *G* (an extension of fuel valve stem) and pressure balancing spring *H*. Provision is made in housing *F* to take a high-pressure fuel inlet hose connection at *J* and a connection at *K* for a flexible hose to take away leakage passing the piston. The end of housing *F* is flanged to take a top cover through which is threaded an adjusting screw *L*. Mushroom valve return spring assembly comprises return spring *M*, spring-retaining ring *N*, clamping nut *O* into which combined stopper and contact pins *P* are a pressed fit, ferrule guides *R* and their securing studs *S*. The mushroom valve is operated in the usual manner by means of cam-operated forked tappet levers. This compresses spring *M* and causes downward opening of mushroom valve. Upon release of tappet pressure on *O*, spring *M* will return valve to its seat. Fuel injection is controlled primarily by the fuel pump in the following manner :—When requisite fuel injection pressure is reached at point of pump discharge, the differential in pressure acting upwards on piston *G* will overcome predetermined pressure exerted by the spring *H* and lift the fuel valve off its seat allowing injection into engine cylinder to take place. Upon a drop in fuel pressure the spring *H* will immediately return the injection valve to its seat. Ferrules *R* will act as guides to the plate *N* during functioning of the mushroom valve and the pins *P* will prevent rotational movement of valve with attendant twisting of connecting hoses at *J* and *K*.—*May* 2, 1956.

748,725. October 8, 1953.—Improvements in Air Supply Means, The National Gas and Oil Engine Company, Ltd., Ashton-under-Lyne. (*Inventor : Joseph Jones.*)

The invention relates to means for supplying air to compression-ignition or spark-ignition engines having an air turbine whose outlet communicates with the inlet manifold of the engine and an air compressor driven by the turbine and arranged to deliver compressed air through a cooler to the inlet of the turbine. Objects of the invention are to provide improved means for increasing the density of the charge air and to enable balanced pressure conditions to be obtained when starting up and when running the engine. As shown in the drawing, a compressor *A* coupled by a shaft to an air turbine *B* receives air from the atmosphere at *C* and passes it by way of a cooler *D* to the turbine *B*, from which air is passed either direct or as shown by way of a moisture trap *F* to the inlet of an auxiliary compressor *G*. Air from the auxiliary compressor is passed to the inlet manifold of the engine *H*. The auxiliary compressor *G* may be driven by an exhaust gas turbine *J*, by an

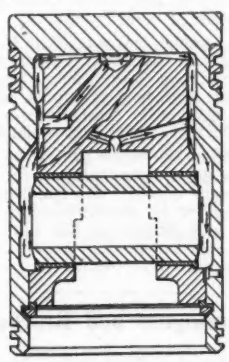


No. 748,725

electric motor *K*, or by some other mechanical drive or combination of any two or more of these power sources. Furthermore, the initial compressor air turbine unit *A*, *B* may have additional power supply to it by an electric motor or other power source *L*, as shown. The electric motor *K* or other driving means such as *L* may be automatically controlled from the temperature and/or from hygrometric conditions of the charging air. The invention provides a means of supplying charge air to the engine *H* at a low temperature, since the charge air is at sub-atmospheric temperature before compression in the auxiliary compressor *G*. It also provides a means of varying the output of either or both compressors *A*, *G*, by supplying power from an external source so that balanced pressure conditions can be obtained when starting up and when running the engine.—*May* 9, 1956.

748,735. November 9, 1953.—The Liquid Cooling of Pistons, D. Napier and Son, Ltd., 211, Acton Vale, London, W.3. (*Inventor : Ernest Edward Chatterton.*)

The invention relates to the liquid cooling of pistons for internal combustion engines and more particularly to pistons for engines in which the rate of heat flow to the piston tends to be high. As will be seen from the drawing, the piston has an annular



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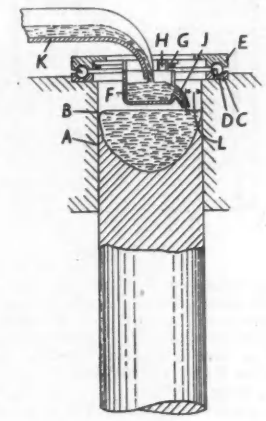
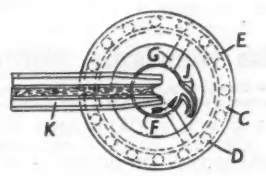
chamber behind the ring grooves extending towards or into the skirt portion and closed at its lower end. A crown cooling chamber extends across the under face of the crown from adjacent to its centre to adjacent to its circumference, where it communicates with the upper end of the annular chamber. A series of loop passages leading from points in the length of the annular chamber to approximately the centre of the crown cooling chamber form means for admitting oil to the chamber. One or more oil outlets for the ejection of surplus oil from the chamber along its length are provided. The arrangement is such that cooling oil thrown to the upper end of the annular chamber during the last half of each upstroke of the piston will tend to pass the lower ends of the loop passages and be forced by its momentum through the crown cooling chamber into the upper ends of the loop passages. During the last half of the downstroke of the piston this oil will tend to be returned downwards to the annular chamber through the loop passages.—*May* 9, 1956.

METALLURGY

748,709. June 22, 1953.—Continuously Casting Metals in Cooled Through-flow Moulds, Siegfried Junghans, Grabenstrasse 60, Schorndorf, Wurttemberg, Germany.

The invention relates to a method of continuously casting metals by means of cooled through-flow moulds. The invention is based upon the discovery that disadvantageous phenomena, such as overlaps or folds, can be avoided by introducing the jet of molten metal into the liquid casting head with a constant change of the point towards which it is directed. The drawing shows a so-called through-flow mould *A* for casting round section billets. The casting level is shown at *B*. At the upper edge of





No. 748,709

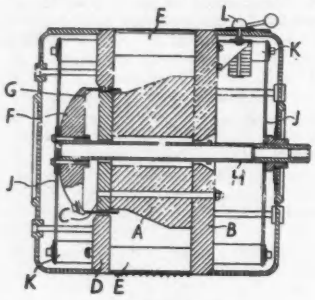
the mould is an annular guide *C* for bearing balls *D*, on which the rotatable supporting ring *E* is mounted. (The drive of the ring is not shown.) The supporting ring carries the distribution vessel *F* by bars *G* and *H*. The channel *J* is curved in the form of a shallow crescent to give a smooth flow of the liquid metal fed to the distribution vessel through the channel *K*, close up to the edge of the mould, that is to say, into the zone which is most influenced by the cooling. The distance *L* between the zone supplied with freshly arriving metal and the wall of the mould depends upon the size of the cross-section of the mould and upon the casting speed, but is, however, limited by the necessity not to disturb the meniscus at the outmost periphery of the casting level as the undisturbed formation of this meniscus has proved to be of considerable importance for a casting with a sound surface. The speed of rotation of the vessel *F* should be so adjusted so that the jet has as little relative velocity as possible against the casting level. This condition is realised when the speed of rotation of the outlet of the vessel is about equal to the flowing velocity with which the jet of molten metal leaves this outlet. In order to keep a constant proportion between the casting speed and the speed of travel of the casting jet, it is expedient to derive the drive of the vessel *F* from the drive of the withdrawing mechanism of the casting machine. In addition, the specification shows a constructional example comprising, in addition to the outlet, extending to the edge of the mould, two further outlets which supply the central and inner zones of the mould cross-section with fresh metal, thus substantially the whole cross-section of the mould.—*May* 9, 1956.

ELECTRICAL ENGINEERING

736,631. July 16, 1952.—Vibration Generating Motors, Goodmans Industries, Ltd., Axiom Works, Lancelot Road, Wembley, Middlesex. (*Inventor : John George Carter.*)

The invention relates to moving-coil vibration generating motors. Referring to the drawing, the motor (which is described in more detail in the co-pending application Specification No. 736,593) includes a permanent magnet assembly comprising a centre pole magnet *A* of substantial dimensions and preferably constituted by a series of sector shape blocks arranged in close juxtaposition to form a pluglike body, an end plate *B* secured to one end of the magnet, a pole tip *C* on the other end of the

magnet, and a pole plate *D* which co-operates with the pole tip to form the requisite air gap, the magnetic circuit being completed by an annular series of spaced rods *E* or by a solid casing connected at its opposite ends to the pole plate and to the end plate respectively. The reverse arrangement may also be employed, namely, a centre pole member of mild steel and an outer magnet consisting of a continuous ring or an annular series of blocks or segments. The armature *F*, which carries and is preferably formed integral with the coil former *G*, is bolted to one end of a driving shaft *H* extending with slight clearance



No. 736,631

through an axial bore in the magnet, the other end of the shaft being screw threaded or otherwise formed for connection to the member to be vibrated. The armature and driving shaft assembly is suspended at each end by centring devices *J* fixed to pillars *K* on the end plate *B* and pole plate *D*. According to the invention, three driving coils are wound upon the former *G* and are firmly bonded to it, and a two-way switch *L* is provided on the outer casing of the motor for connecting the coils in series or in parallel to obtain a coil structure of high or low impedance as desired.—*September* 14, 1955.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

UNIFIED BLACK SQUARE AND HEXAGON BOLTS, SCREWS, NUTS (UNC AND UNF THREADS) AND PLAIN WASHERS—NORMAL SERIES

No. 2708 : 1956. Price 5s. This latest addition to the range of standards for Unified fasteners is intended for bolts and nuts with smaller hexagons than the normal precision and heavy black series, for applications where precision tolerances are not required. The term "black" does not necessarily relate to the appearance of the products, since these may be bright or black in the finished state, but implies the comparatively wide tolerances to which they are usually made.

Square-headed black bolts and square nuts are included in this standard and, in order to achieve full unification, the across-flats sizes are in accordance with those given in the corresponding American standard. A table of heavy hexagon nuts in sizes from ¼in to 2in has been included, since users of the standard may wish to follow what is common practice in the U.S.A., where square-headed bolts are often used, not only with square nuts, but with heavy hexagon nuts.

In addition to the usual general requirements and tables of dimensions, the standard also includes appendices giving formulæ for the calculation of sizes outside the range of the specification, details of identification marking, and tables of approximate weights of bolts and nuts.

PRECAST CONCRETE FLAGS

No. 368 : 1956. Price 3s. This British Standard, which was first issued in 1929, revised in 1936 and amended in 1947, has been reviewed again in the light of present-day practice in the manufacture of concrete flags. Whilst it has been found generally satisfactory, it is considered that assistance would be given to both the purchaser and manufacturer in the choice of aggregates, if reference was made to the appropriate clauses of British Standards for such aggregates. This will enable the purchaser to quote a British Standard where possible. Where the purchaser or the manufacturer wishes to use an aggregate not so provided for, it must be emphasised that one of the requirements of this British Standard is that the purchaser shall approve the aggregate, the interests of both purchaser and manufacturer being protected thereby. Amendments have also been made where possible to secure uniformity with B.S. 340 : "Precast Concrete Kerbs, Channels, Edgings and Quadrants." The omission of specific manufacturing details has again been considered. No reason could be found for departing from the decision made at the last revision, not to include detailed requirements for the manufacture of the flags, but to leave the purchaser to state his requirements.

Launches and Trial Trips

DIOMED, cargo liner ; built by the Caledon Shipbuilding and Engineering Company, Ltd., for Alfred Holt and Co.; length overall 492ft, breadth moulded 62ft, depth moulded to upper deck 35ft 3in, deadweight 9200 tons, service speed 15 knots ; twelve passengers ; six cargo holds, one 70-ton, one 7-ton, eight 10-ton, eighteen 5-ton derricks, electric deck machinery ; two 450kW diesel-driven generators, one 350kW diesel-driven emergency generator ; one exhaust turbo-pressure-charged, single-acting, opposed-piston oil engine, 8000 b.h.p. at 112 r.p.m., one Cochran vertical multitubular boiler. Launch, April 12th.

ATLANTIC KNIGHT, oil tanker ; built by Blythswood Shipbuilding Company, Ltd., for the Ocean Tanker Line, Ltd. ; length between perpendiculars 565ft, breadth 76ft 7in, depth 41ft 2in, deadweight 22,500 tons ; nine centre and eighteen wing cargo tanks, one main pump room, three 680 tons per hour horizontal centrifugal cargo oil pumps, two 180 tons per hour stripping pumps ; one set of double reduction geared turbines by David Rowan and Co., Ltd., 8000 s.h.p. at 105 propeller r.p.m., steam supplied at 450 lb per square inch and 780 deg. Fah. by two Babcock and Wilcox water-tube boilers.—Launch, April 26th.

OTI, cargo liner ; built at Belfast by Harland and Wolff, Ltd., for Elder Dempster Lines, Ltd. ; length overall 450ft, length between perpendiculars 425ft, breadth moulded 62ft, depth moulded to shelter deck 34ft, gross tonnage 5485 ; two complete steel decks, seven watertight bulkheads, four main cargo holds, one 80-ton, one 30-ton and sixteen derricks with lifts from 3 to 12 tons, electric deck machinery ; four 125kW diesel-driven generators ; Harland and Wolff two-stroke, single-acting, opposed-piston oil engine, five cylinders, 620mm diameter by 1870mm combined stroke, 115 r.p.m.—Trial, April 26th.

NARDANA, cargo liner ; built by Barclay Curle and Co., Ltd., for British India Steam Navigation Company, Ltd. ; length 514ft, breadth 67ft 6in, depth to shelter deck 41ft 8in gross tonnage 10,000 ; six cargo holds, twenty 6-ton and 15-ton derricks, electric deck machinery ; four 300kW diesel-driven generators ; one set of Parsons triple expansion, double-reduction geared turbines, 116 propeller r.p.m., steam supplied at 500 lb per square inch and 750 deg. Fah., by two boilers.—Launch, April 26th.

BONAVISTA, passenger and cargo ship ; built by Hall Russell and Co., Ltd., for Canadian National Railways, Montreal ; length between perpendiculars 199ft, breadth moulded 35ft, depth 19ft 6in, deadweight 1000 tons ; fifty first-class and forty second-class passengers ; three holds, electric deck machinery, two 100kW diesel-driven generators, one 50kW auxiliary generator ; Fairbanks-Morse opposed piston diesel engine, 1280 b.h.p., drives through hydraulic coupling and reverse reduction gearing.—Trial, April 23rd.

ASSURITY, coastal tanker ; built by the Goole Shipbuilding and Repairing Company, Ltd., for F. T. Everard and Sons, Ltd. ; length between perpendiculars 265ft, breadth 41ft 6in, depth 17ft 9in, deadweight 2630 tons ; Newbury six-cylinder diesel engine, 1200 b.h.p. at 250 r.p.m.—Trial April 26th.

NORGE MONTI, oil tanker ; built by the Ateliers et Chantiers de la Seine-Maritime, for the Chilean Navy ; length overall 548ft 2in, length between perpendiculars 520ft, breadth moulded 68ft, depth 38ft 10¼in, draught loaded 30ft 1½in, deadweight 17,750 tons, service speed 14 knots ; two 275kW turbo-generators.—Trial, April.

Catalogues and Brochures

HAWKSLEY SMD., Ltd., Slough, Bucks.—Folder dealing with a system for constructing single-storey general-purpose buildings, also giving technical data concerning the method of construction.

STONE-FRY MAGNESIUM, Ltd., Prince George's Road, London, S.W.19.—Catalogue dealing with magnesium alloy pressure die casting, giving details of properties, design, machining and finishing.

GENERAL REFRACTORIES, Ltd., Genefax House, Sheffield, 10.—Leaflet dealing with G.R. "Gunmax" basic compositions designed to increase furnace productivity and reduce shut-down time.

NORTON GRINDING WHEEL COMPANY, Ltd., Welwyn Garden City, Herts.—Leaflet dealing with "Norton G-Bond" grinding wheel, used for centreless, internal and other forms of precision and semi-precision grinding.

DALE ELECTRIC (YORKSHIRE), Ltd., Electricity Buildings, Filey, Yorkshire.—Folder describing a mobile power unit manufactured by this firm, giving technical data and specification with its application in the field of electronics.

TRETOL, Ltd., Tretol House, The Hyde, London, N.W.9.—Descriptive leaflet giving details of a silicone waterproofer that is used as a waterproofing treatment for masonry, i.e. brick, stone, cement rendered and asbestos cement walls.

THE RUBEROID COMPANY, Ltd., Commonwealth House, 1–19 New Oxford Street, London, W.C.1.—Illustrated catalogue entitled "Ruberoid Slates," giving details of a range of asbestos-based slates used as a flexible weather-resistance roofing.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Booklet illustrating a range of "Kuterlite" lightweight compression fittings primarily intended for hot and cold water services and heating installations.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated*

ASLIB

To-day to Mon., June 1st to 4th.—Hotel Metropole, Brighton, Annual Conference.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 1st.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, Annual General Meeting, 6.30 p.m.

Sat., June 2nd.—OXFORD, READING AND DISTRICTS BRANCH : "Lewis Room," The Y.M.C.A., 10, George Street, Oxford, Annual General Meeting, 7 p.m.

Mon., June 4th.—LEEDS BRANCH : Great Northern Hotel, Leeds, Annual General Meeting, 7 p.m.——SHEFFIELD BRANCH : Royal Victoria Station Hotel, Sheffield, Annual General Meeting, 7.30 p.m.

Tues., June 5th.—N.E. LONDON BRANCH : Congregational Church, Court Road, Eltham, Annual General Meeting, 7.15 p.m.——S. WALES BRANCH : Angel Hotel, Westgate Street, Cardiff, Annual General Meeting, 7 p.m.

Wed., June 6th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Annual General Meeting, 7 p.m.——PRESTON BRANCH : Chamber of Commerce, 49a, Fishergate, Preston, Annual General Meeting, 7.30 p.m.——NOTTINGHAM BRANCH : Electricity Board's Showroom Theatre, Smithy Row, Nottingham, Annual General Meeting, 7.30 p.m.

Thurs., June 7th.—N. LONDON BRANCH : Half Moon Hotel, Borad Green, Croydon, Annual General Meeting, 7.15 p.m.

Fri., June 8th.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Annual General Meeting, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Wed., June 27th.—Management House, 8, Hill Street, London, W.1, "The Automatic Factory—Its Evolution and Implications," J. F. Coales, 7 p.m.

CHEMICAL SOCIETY

Thurs., June 7th.—Burlington House, Piccadilly, London, W.1, Centenary Lecture, "Present Status of the Transuranium Elements," G. T. Seaborg, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., June 12th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Small Industrial Water-Tube Boilers," G. H. Steward, 7.15 p.m.

Thurs., June 14th.—MERSEYSIDE AND N. WALES BRANCH : Royal Institution, Colquitt Street, Liverpool, Brains Trust on "Fuel and the Future," 7.15 p.m.

Fri., June 29th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, "Spring Design and the Plant Engineer," A. A. D. Brown, 7.30 p.m.

INSTITUTE OF METALS

Wed., June 13th.—METAL PHYSICS COMMITTEE : Weir Hall, Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, "Some Recent Studies of Irradiation Effects in Metals and Other Solids," R. Smoluchowski, 6.30 p.m.

INSTITUTE OF NAVIGATION

Wed., June 20th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Crossing Antarctica," George Lowe, 5 p.m.

INSTITUTE OF PETROLEUM

Wed. to Fri., May 30th to June 1st.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Symposium on Chromatography, 9.30 a.m. to 12.30 p.m. and 2 p.m. to 5.30 p.m.

Wed. to Sat., June 6th to 9th.—SUMMER MEETING : Palace Hotel, Torquay, "Essential Factors in the Future Development of the Oil Industry."

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., June 14th.—LONDON CENTRE : All-day visit to the works of Simms Motor Units, Ltd., East Finchley, London, N.2.

INSTITUTION OF CIVIL ENGINEERS

Tues., June 5th.—Great George Street, Westminster, London S.W.1, Annual General Meeting, 5.30 p.m.

Mon. to Fri., June 18th to 22nd.—Great George Street, Westminster, London, S.W.1, Colonial Engineering Conference, Monday at 3 p.m. and following days at 10 a.m.

Wed., June 20th.—Great George Street, Westminster, London, S.W.1, Conversazione, 7.45 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Thurs., June 21st.—Royal Festival Hall, London, S.E.1, Conversazione, 7.45 p.m.

Mon. to Fri., June 25th to 29th.—Summer Meeting.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., June 7th.—Weir Hall, 10, Upper Belgrave Street, London, S.W.1, "The Planning Performance, Pressures and Stresses in a High-Speed Launch," P. Du Cane, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., June 2nd.—N. MIDLANDS REGION : Town Hall, Peterborough, Regional One-Day Conference, "Aspects of Automation," 10 a.m.

INTERNATIONAL MACHINE TOOL EXHIBITION, 1956

Fri. to Fri., June 22nd to July 6th.—Olympia, London.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Tues., June 12th.—Summer Meeting.

NORTH WESTERN FUEL LUNCHEON CLUB

Wed., June 6th.—Engineers' Club, Albert Square, Manchester, "Coal in the Atomic Age," E. F. Schumacher, 12.45 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., June 18th.—12, Great George Street, Westminster, London, S.W.1, "Research and the Rural Landowner," His Grace the Duke of Northumberland, 2.15 p.m.

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION

Wed. to Fri., June 6th to 8th.—ELECTRONICS SECTION : Royal West of England Academy, Bristol. Exhibition, "Atoms, Electrons and Industry."